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ABSTRACT

This document contains twelve reports which were presented at the Seminar on Training Policies for Computer Manpower and Users held in Paris, May 1973. The seminar was sponsored by the Computer Utilization Group of the new Organization for Economic Co-operation and Development (OECD). Reports were submitted on the following topics: characteristics and general trends in informatics, the quality of future computer specialists' education, responsibility for training in information processing, training for management, philosophy and contents of training for computing, computer science in secondary education, costs and technical facilities for training, career profiles in EDP, recurrent and permanent education and training, impact on social structures of computer science training in education systems and a demand forecast survey of information processing engineers in Japan. A statement of conclusion and recommendation concerning training policies was drafted in early 1974 by experts in the field and is included, in this document. An appendix lists names and addresses of delegates, experts, and observers attending the seminar. (CH)

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training policies for computer manpower and users

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ANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT PARIS

Publié en français sous le titre :

**POLITIQUES DE FORMATION DES SPECIALISTES
ET DES UTILISATEURS DE L'INFORMATIQUE**

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INFORMATICS STUDIES

9

training policies for computer manpower and users

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6

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Forthcoming Studies

10. POLICY ISSUES IN DATA PROTECTION AND PRIVACY
11. INFORMATION TECHNOLOGY AND ITS APPLICATION TO THE HEALTH FIELD

CONTENTS

Preface 7

Part One

I. STATEMENT OF CONCLUSIONS ADOPTED BY THE GROUP ON TRAINING POLICY ISSUES FOR COMPUTER MANPOWER AND USERS 11

II. LIST OF MEMBERS OF THE DRAFTING GROUP 15

Part Two

REPORTS SUBMITTED AT THE SEMINAR ON TRAINING POLICIES FOR COMPUTER MANPOWER AND USERS

Paris, 21st, 22nd, 23rd May, 1973

I. CHARACTERISTICS AND GENERAL TRENDS by Pierre M. Martin 19

II. COMPUTER SCIENCE AND THE QUALITY OF FUTURE COMPUTER SPECIALISTS' EDUCATION by Gerhardt Seegmüller 42

III. WHO MUST ASSURE THE TRAINING - PUBLIC AUTHORITIES, PRIVATE INSTITUTIONS OR MANUFACTURERS? by Wladimir Mercouroff 49

IV. WHO MUST ASSURE THE TRAINING - PUBLIC AUTHORITIES, PRIVATE INSTITUTIONS OR MANUFACTURERS? by Jacques F. Blackburn 56

V. SPECIFIC TRAINING FOR MANAGEMENT by Daniel Teichroew 64

VI. PHILOSOPHY AND CONTENTS OF TRAINING FOR COMPUTING by Aaron Finerman 81

VII. COMPUTER SCIENCE IN SECONDARY EDUCATION by Jacques Hebenstreit 93

VIII. THE COSTS AND TECHNOLOGICAL FACILITIES WHICH TRAINING INVOLVES by Jacques Suchard 105

IX. CAREER PROFILES IN EDP
by Fernando Piera Gomez 113

X. RECURRENT AND PERMANENT EDUCATION AND TRAINING
by François Bodart 122

Annex: Nomenclature used in a Data Processing System 129

XI. IMPACTS ON SOCIAL STRUCTURES CONSEQUENT UPON THE INTRODUCTION OF TRAINING FOR COMPUTER SCIENCE INTO THE EDUCATION SYSTEM
by M. Henderson 136

XII. DEMAND FORECAST SURVEY OF INFORMATION PROCESSING ENGINEERS IN JAPAN
by S. Imamura 146

ANNEX

List of National Delegates, Experts and Observers attending the Seminar 167

PREFACE

The Computer Utilisation Group, set up in 1968 by the OECD Committee for Science Policy(1) in response to recommendations of the third Ministerial Meeting on Science, has on its programme studies in the fields of computerised data banks, interaction of computers and telecommunications, computer manpower education, computer utilisation surveys, efficiency audits for computer systems, potential of information technology in urban and regional planning and information technology and its applications to the health field.

The present report highlights policy issues concerning the training policies for computer manpower and users, and consists of two parts:

I. The statement of conclusions adopted by the Group of Experts in this field (meeting of 10th and 11th January, 1974).

II. The background reports submitted at the Seminar held in Paris on 21st, 22nd and 23rd May, 1973.

The views expressed in the background reports are those of the authors alone and do not necessarily reflect those of the Group of Experts, their governments or the OECD Secretariat. The conclusions of the Drafting Group whose names appear on the attached list were drawn up by its members and consequently do represent their collective opinion. However, they have not been co-ordinated formally with Member governments and they should not therefore be construed as constituting the official policies or opinions of those governments.

---

1) Now the Committee for Scientific and Technological Policy.

Part One

I. STATEMENT OF CONCLUSIONS ADOPTED BY THE GROUP ON TRAINING POLICY ISSUES FOR COMPUTER MANPOWER AND USERS
(10th and 11th January 1974)

II. LIST OF MEMBERS OF THE DRAFTING GROUP

I

STATEMENT OF CONCLUSIONS

Modern society is now beginning to realise that some growth problems apparently cannot be dealt with on the basis of old formulas. Until now, a certain measure of physical or human resources was available, and the rough approach in order to meet increasing demand was to draw on them in proportion to requirements. The shortage of resources which is now making itself felt requires a new formula for growth, and a possible solution would be to find an approach which would have a multiplier effect on the resources/requirements ratio. This can presumably be achieved by better organisation, since the various problems confronting modern society are increasingly interrelated and more methodical handling may be expected to optimise the use of resources.

A key role in such an organisation is the circulation, processing and dissemination of information which, if used systematically and rationally, will have a beneficial effect on the social and cultural as well as economic development of modern society.

Informatics is the special tool which can be used for organising information. In the present context it has a number of outstanding advantages: it uses little energy, few raw materials and does not pollute the physical environment, while it draws on intellectual rather than physical human resources. The problems of training in informatics, which are largely new problems, should therefore be a major concern; such training should teach people to make the most of what it can offer as well as protect them from any danger its use may involve.

The introduction of this systemised training can no longer be delayed, since otherwise the advantages of the informatics tool will decline as fast as it comes into wider use.

The computer's growing workload means that an ever increasing amount of resources must be used. The overall costs - of hardware and especially software - are rising to such an extent that adequate training which can minimise these costs is of the utmost urgency.

Moreover, it will be realised that the higher the level reached by education, the greater the production and demand for information.

The result is the exponential growth of the amount of information available, which inevitably raises the question of how to select what is relevant.

This new problem is not only one of technology but far more of how informatics should be used in all disciplines, i.e. of how its methodology should be applied in each.

Considering, therefore, that:

- the scope of informatics is rapidly increasing;
- it is becoming a part of all human activities;
- educational systems are subject to certain constraints,

a broad, effective curriculum of general scope should be promptly drawn up providing initiation and instruction in the methods and techniques of informatics.

The various training programmes should not be approached from a purely vocational aspect. Since informatics is "the science of the rational processing of information regarded as a knowledge and communication medium in the technical, economic and social fields", it has a cultural as well as technical aspect, and its development can be compared to the spread of literacy. Training can therefore be divided into three interdependent categories:

a) Educational and general cultural requirements

Citizens in our modern countries must be made constantly aware that informatics exists and is needed by being shown how it can be used, what it can do and what its limitations and dangers are.

b) Training requirements for users

Enough about the methodology of informatics, meeting the specific needs of each human activity should be taught enabling people to use it in their work.

c) Training requirements for computer technicians

The purpose here is to train specialists whose main activity is connected with informatics technology and who are also concerned with the problems to be dealt with.

Informatics training for users and for specialists alike has almost always consisted of courses dealing with the structure and operation of computers and with one or more programming language.

As the methodology of informatics can greatly affect many disciplines, it is recommended that it can be included in all types of courses rather than taught as a separate subject in the general curriculum.

Informatics is a fundamental science whose main features are its object, i.e. information, and its methodology, especially model-building.

The teaching of this methodology, which is at the core of informatics, requires that teaching content and methods be studied from an informatics standpoint and that teachers from all disciplines be effectively trained in informatics methodology.

The introduction of informatics at all educational levels requires that all teachers be trained in informatics methodology as applying to their particular discipline.

Owing to the urgency of the problem, it is essential that practising teachers be retrained, otherwise a great deal of time will be wasted.

Retraining should in no case merely deal with the structure of computers and/or programming languages, but should broadly approach the problem of imparting a knowledge of informatics methodology to students in terms of the various disciplines which are taught.

The handling of information by the computer is rapidly growing and will increasingly involve all citizens of a country in varying personal degrees. If this process is to take place in an acceptable and reasonable way, both public and private enterprise must realise that they have an obligation to keep their customers informed of the consequences of present and future developments.

Public and private organisations which are or will be using electronic data processing systems which might involve the general public are advised to make far greater use of mass media techniques (television, radio, films, publications and lectures, etc.), which can best inform the general public of the implications and advantages of modern data processing techniques.

Owing to the rapid advances made by informatics in many countries, computers were introduced before a system could be set up for training manpower. Training in the use of computers was therefore provided for some time by the computer industry.

This type of course is not only useful for training and retraining technicians but should be a normal feature of the manufacturers' services. It is recommended, however, that general training in informatics at all levels of education should be taken over by the authorities under the national education system.

The cost of developing and improving facilities for providing training is high, and some countries are not equipped for the purpose. The more experienced countries are therefore asked to encourage and support measures for setting up and promoting facilities for exchanging informatics training experience.

Informatics and the way in which it is used are rapidly changing. Consequently, all those directly or indirectly connected with this field need to undergo periodic retraining to keep abreast of steadily changing requirements.

It is therefore recommended that all levels of training in informatics be regularly examined in the light of continuing education requirements, with the object of maintaining and improving national and international skills in this field.

II

LIST OF MEMBERS OF THE DRAFTING GROUP

Mr. R. Dierstein	DFVLR, Computers Division	Oberpfaffenhofen (Germany)
Mr. R. T. Filep	University of Southern California	Los Angeles (United States)
Mr. H. P. Gassmann	OECD Secretariat	
Mr. J. Hebenstreit	Ecole supérieure d'électricité	Paris (France)
Mr. P. M. Martin	OECD Secretariat	
Mr. W. Mercouroff	Ministry of Education	Paris (France)
Mr. G. Pâris	Public Administration, Prime Minister's Office	Brussels (Belgium)
Mr. E. G. Sabourin	Department of Supply and Services	Ottawa (Canada)

Part Two

REPORTS SUBMITTED AT THE SEMINAR ON TRAINING POLICIES FOR COMPUTER MANPOWER AND USERS

Paris, 21st, 22nd, 23rd May, 1973

I

CHARACTERISTICS AND GENERAL TRENDS

by
Pierre M. Martin
OECD Secretariat

Informatics forms an integral part of our daily environment, permeating all branches of social activity and often insidiously invading individual privacy. An essential factor in a country's economy, ..."it seems certain that between 1970 and 1980 it will become the third world industry after oil and motor vehicles".(1)

The OECD countries' interest in the training of computer manpower and users stems from the fact that several countries have no policy for training computer specialists and even less for educating users and the public. Many decision-makers at all levels and even some specialists are still apt to consider informatics as a tool for making speedier calculations and handling more statistics rather than a methodology for generating new concepts.

To meet the pressing demand for immediate results, make up for the shortage of teachers and experts, remedy the lack of any government computer training policy and in order to improve professional standards, computer manufacturers at the outset played a decisive role in computer training. Based on computer utilisation, courses were intended for specialists who often became dependent on a given type of machine, with the result that the educational aspect of informatics was completely ignored. The manufacturers introduced rigid manpower structures which satisfied their immediate needs but did not really take fundamental problems into account or needed computer training policies.

Computer specialists have often made users select a particular type of computer or "package", but owing to improved user training and the development of mini- and micro-computers, they have increasingly less to say in decision-making and are concerned with only technical matters. The result of introducing informatics into the

---

1) "Une politique communautaire de l'informatique", SEC(73)4300, Commission of the European Communities.

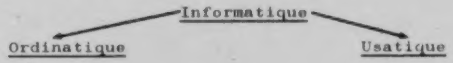
public and private sectors has generally been that information and its processing have become centralised and increasingly powerful computers are being used on the strength of GROSCH's Law, which is that: "The power of a computer is proportionate to the square of its cost". To extend centralisation to all fields of computer applications would not seem to be desirable owing to the danger of social conflict.

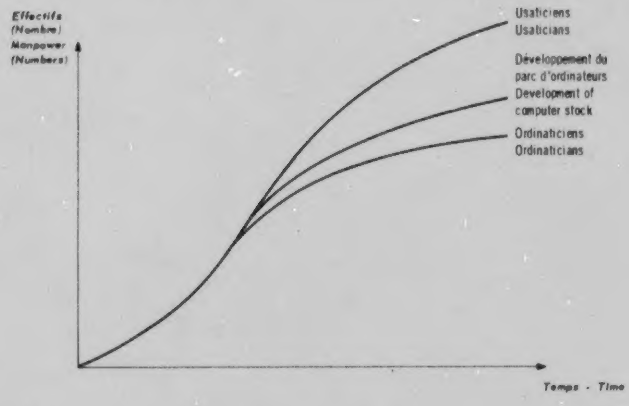
It is fitting, before starting this study, to differentiate in the word INFORMATIC (Computer Science), two words which are ORDINATIC and USATIC in order to clarify the problem. The syntactic and semantic aspects of these two words are, for the moment, secondary, the essential being to distinguish two types of people who gravitate around the electronic computer, representing two very different types of training.

"L'ordinatician" is a computer specialist who works in the research, the computer operation, the programming, the system design and who receives a high technical education.

"L'usatician" [a concatenation (mixture) of "user of" or "usager de" l'informatique], is a doctor, a sociologist, a jurist, a town-planner ... and must be able to conceptualise his specific problems in terms of what the computer as a tool can do.

The following is a rough diagram of the development of computer manpower requirements.





The authorities should take a more active interest in computer education, in particular:

- By arranging for educational aspects to be taught as part of general education and continuous training;
- By defining certain high standards for training given in private institutions along the lines of:
  - DIFAD (Data-Processing Institute in Germany) which has set up a Committee for examining students from private institutes;
  - the Stichting Studie Centrum in the Netherlands;
  - etc.
- By setting up institutional and financing facilities required for the continuous training of teachers, especially in usatic.

The problems of teacher-training vary considerably according to the state of the art in OECD Member countries. A distinction should be made between two types of country, namely:

- the more advanced countries, which need to slow down training in ordinatic and speed up that in usatic;
- the countries where informatic is less developed. These countries need to speed up initial ordinatic training with the help of manufacturers under the supervision of the authorities, the object being to meet immediate requirements and later introduce usatic.

Public surveys are needed, moreover, to determine requirements for training in the educational aspects. For instance, the tables 1 to 4(1) taken from a "National Survey of the Public's Attitudes towards Computers", issued by the AFIPS and Time Magazine (1972), show how people feel about computers and their use. The enquiry, conducted by Lieberman Research Inc., concerns only the United States and deals with a sample of 1,001 persons over 18 years old questioned by telephone for about 35 minutes.

* * *

Ordinaticians must have a certain number of "aptitudes" and knowledge concerning certain tasks to be carried out and certain functions to be assumed. The following, not necessarily complete list, is based on:

- the list of tasks contained in the OECD report DAS/SPR/72.49, amended by Van der Noot(2) and modified by Lund Jensen and W. Rasmussen(3). (The list contains 101 elementary tasks);
- a list given to the Secretariat by Professor Teichroew at the seminar held in May, 1973. It includes 114 "tasks" and "ability to's" or "knowledge's".

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1) See Annex pp. 37 to 41.

2) Special Advisor, Ministry of Public Works, Canada.

3) Director, Ministry of Education, Denmark.

All the sentences begin with "ability to":

1. Programme in file-oriented languages (COBOL, RPG).
2. Programme in scientific or algorithmic type languages (FORTRAN, PL/1).
3. Programme in an assembler type language (BAL, COMPASS).
4. Programme in simulation languages (GPSS, SIMULA).
5. Analyse and evaluate programming languages for selecting the most appropriate language for solving a given problem.
6. Prepare sample data for programmes and providing test runs.
7. Analyse programmes outlined by systems analysts for detailed design and construction.
8. Convert existing programmes from one system to another (language to language, computer to computer).
9. Use programme testing aids (debugging packages, traces and snapshots).
10. Analyse and evaluate different software applications packages.
11. Revise existing programmes (including debugging and refinement).
12. Use sort and utility packages.
13. Design and use input and output layouts.
14. Use sequential and index sequential file techniques.
15. Use direct or random file techniques.
16. Create, maintain and interrogate files.
17. Design and use decision tables.
18. Design and use run and grid charts.
19. Write detailed programme specifications.
20. Present in writing a summary of a project for management action (suitable to serve as a basis for decision).
21. Prepare clear and suitable documentation (programmes and programming procedures, systems, etc.).
22. Prepare effective user documentation for either a portion of a system or an entire system.
23. Communicate with others verbally (in general).
24. Co-operate and work effectively with others.
25. Perform tasks accurately.
26. Manage other people.
27. Accept responsibility and initiate action.
28. Train and develop subordinates.
29. Help the user to compile and analyse data.
30. Initiate the user into data preparation methods.
31. Initiate the user into output interpretation.
32. Initiate the user into the use of mini- and micro-computers and terminals.
33. Help the user to define his needs.
34. Make the firm's staff aware of the computer's potential.
35. Inform those responsible of the problems involved in collecting private data.

36. Help to introduce computer training and awareness policy in the firm or organisation.
37. Predict alternate future behaviour of individuals and groups (e.g. predict individuals' reactions to operating changes).
38. Articulate and defend a personal position on some important issue of the impact of information technology and systems on society (important as defined by Congressional interest, public press and semi-technical press, etc.).
39. Complete assignments on time.
40. Work effectively under pressure.
41. Motivate self and others and create in others a willingness to discuss problems.
42. Work independently with limited supervision.
43. Formulate and solve simple management science type models (linear programming, dynamic programming, queuing and simulation).
44. Recognise the appropriate management science (operational research) models for situations commonly encountered.
45. Identify in an on-going organisational situation the key issues and problems of a given functional area (production, finance, marketing, etc.).
46. Describe and identify individual and group behaviour (e.g. describe and identify working relationships among people in an organisational environment).
47. Develop specifications for a major information system addressing a given organisational need, and determine the breakdown into manual and computer-based parts.
48. Apply the "system viewpoint" in depth within the organisation structure.
49. Delegate assignments and review the results of assignments directly under control.
50. Identify possible long- and short-term effects of a specified action on organisational goals.
51. Analyse communication systems (estimate line and terminal requirements, volume and message length, queues, etc.).
52. Evaluate system-performance and make needed adjustments to system after implementation.
53. Determine the major alternatives in specifying an information processing system including data files and communication structures.
54. Make "rough cut" feasibility evaluations of proposed new techniques or applications of current technology.
55. Analyse and evaluate different hardware configurations.
56. Design software and hardware configurations.
57. Handle a number of assignments simultaneously.

58. Design and use flowcharts (system and programme).
59. Use interactive debugging facilities (available through a time-sharing arrangement such as Text-Editor).
60. Perform economic analyses (cost/benefit studies) of the proposed resource commitments for a project.
61. Analyse and determine cost/benefits analysis of project (information system) to user.
62. Calculate cost/performance trade-offs in a system.
63. Develop positive and negative impacts of a specified information system on specified parts of an organisation.
64. View, describe and define any situation as a system.
65. Plan and organise work assignments.
66. Propose master plans for an overall computer policy in a firm or organisation.

The following part deals with a knowledge of the concepts and areas set out below:

A. To assist in the rating process it is suggested that an individual who could prepare a "technically correct" paper of about 500 words would be considered to rank as "superior".
B. All sentences begin with the words "knowledge of":

67. Existing communication facilities (line types exchanges, utilities).
68. Communications access methods and their general features to support terminal/teleprocessing applications.
69. Sorting techniques (radix, merge, bubble tree).
70. Searching techniques (sequential, binary, directory).
71. Characteristics of auxiliary storage devices (capacity access, storage): tape, disk, drum, etc.
72. Input-output devices (types existing on the open market).
73. Operating systems (including scheduling algorithms, memory and peripheral management, interrupt systems).
74. Micro-programming, multi-programming and multi-processing, time-sharing operating system (concepts and facilities).
75. Queuing structures.
76. Job control languages (coding and techniques).
77. The "inner workings" of compilers, interpreters or other translators.
78. Multilink data structures (trees, multilist, inverted list, networks, etc.).
79. Data gathering techniques (interviews, etc.).
80. Performance evaluation techniques (simulation packages, hardware and software monitors).
81. Mini-computers and micro-computers.
82. Public and private data banks.

83. The need for security in programmes, data storage and work flow design as well as physical protection of programmes and data.
84. Computer impacts on industrial, clerical and managerial positions.
85. Elements and relationships of information in various functional segments of the organisation.
86. The computer industry with regard to growth patterns, competition and government regulations.
87. Sources for updating knowledge of technology.
88. "Outside" computer services (information concerning consultants, software houses, application packages, etc.).
89. Corporate policy and lines of authority and responsibility.
90. Standardisation practices in the computer industry.
91. Project planning and control tools [techniques for project scheduling and controlling (PERT), critical path methods (CPM) etc.].
92. General systems theory (open - closed systems, system boundaries, feedback concept).
93. Accounting practices and procedures and models for inventory control.
94. Elementary statistics and fundamentals of the probability theory.
95. Matrix algebra.
96. Differential calculus for optimisation.
97. Set theory.
98. Potential applications of automated processes for society.
99. Professional data-processing associations.
100. Changes in employment patterns as a result of automation.
101. Calculating manpower needs and recruiting.
102. Flow chart operation.
103. Division into part systems and routines.
104. Studying and selecting existing routines.
105. Selecting required programming language.
106. Desk checking programme logic.
107. Programme file organisation.
108. Programme file description.
109. Debugging programmes.
110. Programme and file storage.
111. Preparing programme and operating documentation.
112. Establishing procedures for programme execution.
113. Describing automatic and manual procedures.
114. Establishing operating standards.
115. Organising activities of EDP-records library section.
116. Preparing operating statistics.
117. Preparing programme machine runs.
118. Defining requirements of the control system.

119. Supervising the machinery and securing necessary maintenance.
120 Taking responsibility for punching (by hand) and verifying.
121. Supervising the activities of the "Programming" Section.
122. Supervising the activities of the Software Section.
123. Supervising the activities of the Operating Section.

* * *

Reverting to the division of informatic into usatic and ordinatic manpower needs usually seems to have been overestimated, since qualitative changes have seldom been taken into consideration. Many forecasting studies have thus been made to determine computer manpower requirements on the basis of the following indicators:

A. Man/machine coefficient;
B. Number of computer specialists per million inhabitants;
C. Number of computer specialists in terms of the value of computers installed.

In every case, the increase in computer stock was used as a parameter, the general assumption being that there would be an annual 15 to 30 per cent increase.

The following are a few examples of these estimates.

A. Man/machine coefficient

NUMBER OF COMPUTER SPECIALISTS PER 100 COMPUTERS IN 1968 AND 1975(1)

Function	Small computers		Medium-sized computers		Large computers		Weighted average	
	1968	1975	1968	1975	1968	1975	1968	1975
Analyst	114	192	308	403	546	544	265	340
Programmer	228	336	506	585	1,029	816	467	520
	342	528	814	988	1,575	1,360	732	860
Operator	258	272	286	312	525	340	305	300
	600	800	1,100	1,300	2,100	1,700	1,037	1,160

1) Study Centre for Computer Utilisation in Administration - "Werken in de automatisering" (Job Descriptions and Training Criteria); N. Samson, Alphen aan de Rijn, September, 1968.

Forecasts partly confirmed by the following table(1)

Staff	1971		1972		1973		1974(2)	
	No.	%	No.	%	No.	%	No.	%(2)
According to enterprises:								
Managerial grades....	1,698	19	1,833	19	1,953	18	2,005	18
Senior technicians	1,954	22	2,207	22	2,406	23	2,506	23
Technicians	2,975	33	3,260	33	3,480	33	3,643	33
Operators..	2,341	26	2,597	26	2,773	26	2,897	26
	8,968	100	9,897	100	10,612	100	11,051	100
Yearly variation in percentage	19%		10%		7%		4%	
According to the Sixth Plan	9,500		11,300		14,600		17,300	
Yearly variation in percentage	20%		19%		29%		18%	

1) "L'informatique dans les entreprises publiques au 1er Janvier 1972", Délégation à l'Informatique, France.

2) The anticipated man/machine ratio of between 11 and 12 during the Sixth Plan corresponds to present of enterprises.

Brandon's formula as set out below(1) was partly used and slightly changed in Japan.

Size	Formula
Super large	$d = a + 0.6b$
Large	$d = 0.95a + 0.6b$
Medium	$d = 0.7a + 0.7b$
Small	$d = 0.75a + 0.8b$

where a = number of installed systems

b = number of systems to be installed at that time

c = adjusted number of systems for prediction.

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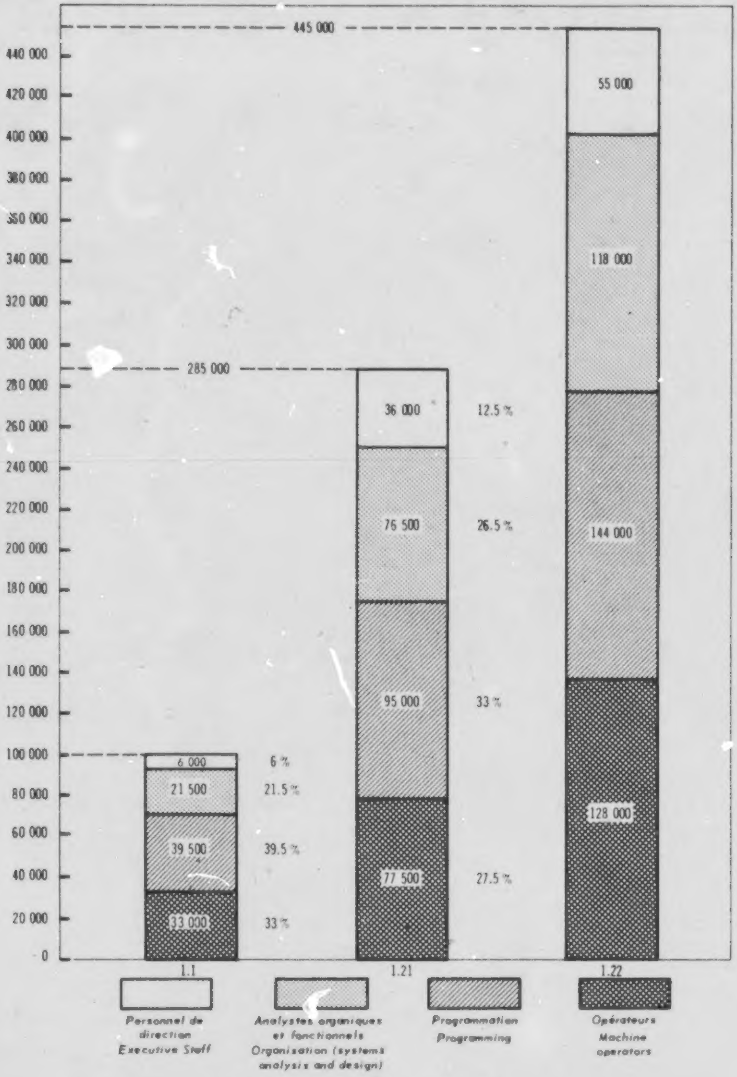
1) Institute of Information Technology, Japan, OECD Document DAS/SPR/73.53; Demand Forecasting Survey of Information Processing Engineers in Japan. Compiled and Commented by S. Imamura.

PREVISIONS POUR L'ALLEMAGNE* - FORECASTS FOR GERMANY*

Structure du personnel - Personnel structure



1.1 Structure du personnel en 1970. - Personnel structure in 1970.
1.21 Structure du personnel prévue en 1978 (estimation minimale).
Expected personnel structure in 1978 (minimum estimate).
1.22 Structure du personnel prévue en 1978 (estimation maximale).
Expected personnel structure in 1978 (maximum estimate).

* D'après une étude effectuée par le Dr. P. Heyderhoff et M.P. Gerkin de la Société de mathématiques et de traitement de données.
Study undertaken by Dr. P. Heyderhoff and Mr. P. Gerkin of the Society for Mathematics and Data Processing.

B. Number of computer specialists per million inhabitants

According to Prof. Zemanek of Vienna University:
- 300 high-level specialists;
- 900 university graduates;
- 1,500 holders of secondary school leaving certificate;
- 2,100 graduates from vocational courses.

C. Number of computer specialists in terms of the value of installed computer stock

Mr. Engberg defines the (PD_r) relation(1):

P = personnel
D = dollars

and applies it to the various countries.

THE PD-RELATION IN VARIOUS COUNTRIES

Country	The PD-relation (personnel per 1 mill. US $)				Average value mill. Danish croner	Number of computers	Time for the census month year
	S	P	D	Total			
1. Denmark	8.1	8.6	7.5	24.2	3.9	352	9.70
2. Norway	13.2	9.4	10.0	32.6	2.6	249	10.71
3. Sweden	5.7	8.0	7.2	20.9	3.8	486	6.68
4. Switzerland (1)	8.4	7.3	5.9	21.6	3.6	1.060	12.69
5. Japan	7.0	9.9	9.1	26.0	2.7	4.224	3.70
6. Netherlands (1)	8.4	10.2	8.0	26.6	3.9	1.192	12.70
7. France	15.8	16.0	14.0	45.8	2.3	4.242	1.69
8. United Kingdom	10.3	15.3	9.4	35.0	3.2	3.875	3.70
9. Germany	10.0	10.4	8.5	28.9	2.3	7.010	1.71
10. U.S.A	8.1	9.5	9.4	27.0	2.7	45.792	6.69

S = System analysis and design + system management
P = Programming, including programme management
D = Operations (operators + chief punch operators)

1) Average value and number of computers is for computers about 0.4 million D.cr. = 60,000 US $.

While training in usatic should be a component part of general education, training in ordinatic should instead be specific. Forecasts of computer manpower needs should therefore only cover ordinaticians. A list of indicators should therefore be drawn up so that the supply and demand can be planned by means of models.

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1) The PD-relation is calculated on the basis of the M/C-ratio, the number of computers and the average value, including MINI. The exchange rate is 1 US $ = 7 D.cr. The other rates are per spring 1972, except for Sweden: 1 Sw.cr. = 1.35 D.cr. (June 1968).

Computer Job Classification (Table, pages 31-36)

The purpose of the following classification is to define the present situation as regards computer jobs and attempt to make a synthesis of the many existing classifications.

Column 1: Job description;

Column 2: Brief description of function;

Column 3: Appropriate training level for job.

"The classification of Educational Systems in OECD Member countries" issued in 1973/74 was used as a reference for defining the various levels, as follows:

Level 1: End of compulsory schooling or first cycle of technical secondary education;

Level 2: End of technical secondary or general secondary education of types A and B;

Level 3: End of non-university type higher education;

Level 4: End of university type higher education.

Column 4: The purpose of using a coefficient is to enable the jobs to be compared more easily. Wages are averaged for four countries (Germany, Canada, France and the United Kingdom) and it is of only relative value owing to the variety of jobs in informatic. The job vacancies advertised in specialised newspapers or articles on computer manpower wages in periodicals (e.g. the May 1974 number of Datamation) were used to calculate the coefficient. The periodicals mainly used were: the Computer Weekly, Computerworld, Die Computer Zeitung, Informatique et gestion, 01 Informatique and Datamation.

. By adding the list of "ability to's" and "knowledge of's" which can be associated to the computer job classification, a matrix can be obtained accurately defining jobs and content.

. The job of scientific programmer is no longer included in the classification and jobs now entered under PROGRAMMING should ultimately be transferred to DESIGN.

. The Data administrator will be responsible for defining and organising data for management and decision-making, and since the post will become very important, a pluridisciplinary type of further training should be introduced for ordinaticians at level 3 or 4.

. Registers for ordinaticians should be created so that the profession will be recognised as a profession, ordinatic and teaching staff obtain the same status as teachers of other subjects thus providing the trade associations with greater influence.

COMPUTER JOB DESCRIPTIONS

I. Data Acquisition

Name of Post (1)	Job Description (2)	Level of Training (3)	(4)
Coder	Translates source and turn-around documents into conventional numeric codes accepted by the computer.	1	150
Punch operator	Transcribes data on to input media by means of electronic or mechanical equipment. Knows the various card formats used and is capable of preparing control cards. (7,000 punches per hour; errors: 2 per cent; waste: 5 per cent). Must be able to adapt to other media (e.g. magnetic stores).	1	150
Verifier operator	Verifies the punched card by means of electronic or mechanical equipment. Must be capable of verifying 8,000 punches per hour. Must not overlook any discrepancy.	1	170
Keypunch supervisor	Has a specialised knowledge of the make of card punch and verifier used, distributes the work and sees that it is carried out accurately. Has received some training in data-processing. Prepares control cards and keeps files of card and record formats up to date. Must maintain a good working atmosphere and is responsible for training beginners.	(1 plus experience) 2	200

II. Data-Processing Environment

Data control clerk	Has a very good knowledge of filing systems and the structure of the enterprise. Sees that data are standardised and co-ordinated in agreement with users, systems analysts and operating staff. Responsible for security of data.	3 4 (according to size of enterprise)	400 650
Librarian	Responsible for storing, "generating" and preparing all media and for their distribution.	2	200 .../

Name of Post (1)	Job Description (2)	Level of Training (3)	(4)
Librarian (cont)	Carries out any administrative work for controlling and if necessary following-up these operations. Applies rules prescribed for: - maintaining input media ready for use; - preventing alerts and the destruction of files and programmes; - privacy.		

III. Operation

Operator (large configurations)	Works in the computer room. Carries out duties associated with the operation of peripheral equipment, whether or not connected to the central unit, under the supervision of and following instructions from the console operator. Sees to the input and output of media of all kinds used at the time of operation. Responsible for smooth operation of the peripheral units he supervises. Carries out such tasks as cleaning and general maintenance as instructed by the operations manager.	1	150
Operator - terminals - calculators	Responsible for operating a terminal. In charge of filing and test data. Should have some general knowledge regarding the use of this small computer (book-keeping, statistics, etc.).	2	200
Console operator	Works in the computer room under the ultimate authority of the operations manager. Responsible for operation of the computer by interrogating the operating system. Endeavours to optimise computer operations as determined by the system's resources and the type of work involved.		
A level	Co-ordinates the activities of peripheral operators. Analyses and interprets messages enabling him to: - control operation of the system; - take any needed action or inform the operations manager in the event of an alert. Advises the operations manager when decisions are taken on alerts. Receives training needed for the particular job.	2	220 .../

Name of Post (1)	Job Description (2)	Level of Training (3)	(4)
Console operator(cont)			
B Level	A level plus: - Multiprogramming, real time and teleprocessing techniques; - Considerable previous experience.	2 or 3 (plus experience)	280
C Level	A and B levels plus: - Administrative skills; - Teaching skills.	2, 3	350
Operations manager C	Full responsibility for computer operations. Helps in formulating decisions concerning staff and equipment at management level. Ensures liaison with manufacturers. Is completely familiar with operating systems of equipment used.	3 or 4 (plus experience)	400 to 750 according to size of department

IV. Programming

Programmer	Applications programmer Writes programmes in symbolic language (FORTRAN, COBOL)		
A Level	Handles simple problems (management, science). Documents his programmes and ensures their maintenance.	2	220
B Level	Programmer analyst Sound knowledge of programming. Must be capable of undertaking simple types of analysis. Able to define any required files and programmes.	2 (plus experience)	280
C Level	Functional programmer Plans, organises and controls the preparation of programmes. Co-ordinates the work of the A and B level programmers. Helps to train A and B level programmers.	3, 4 (plus experience)	350

V. Design

Analyst	Systems analyst Conversant with operating systems and programming techniques.		.../

Name of Post (1)	Job Description (2)	Level of Training (3)	(4)
Analyst (cont)			
A Level	Formulates and controls new applications. Prepares technical notes and application procedures. Is the link between the systems designer and the programmer.	3	280
B Level	Systems project manager Is a technician who has complete mastery over the technical phase of systems analysis and is capable of: - helping, together with an engineer, to solve the problems he defines; - helping to introduce new methods and relevant procedures; - organising meetings for studying technical problems and needed liaison between the various services. - searching data and promoting the generation of new data. - preparing and submitting summary technical reports on his work.	3, 4	360
C Level	Systems designer, Project leader Plans, organises and controls the activities of a team of analysts and programmers working on a specific project (such as a data bank). Co-ordinates his activities with those of other sections. Prepares specifications.	4	500
Head of Computer Department	Responsible for Computer Department (computer up to 64 K octets). Thorough knowledge of equipment and managerial problems in the enterprise. Plans, organises and controls all Computer Department activities. Acts as adviser to other departments.	3 or 4 according to size of configuration	400 to 700 according to size of configuration
Data-processing manager	Attached to General Management. Has the same tasks as those of the Head of Computer Department.	4	700 and over

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VI. Other Posts

Name of Post (1)	Job Description (2)	Level of Training (3)	(4)
Technical sales representative	Fully conversant with his company's equipment, helps the customer with its installation and instructs him in its rational use.	3, 4	350 to 500
Sales representative	Fully conversant with his company's products and if possible with those of other companies. Is a skilled salesman. Helps to prepare the specifications and current application systems. Maintains regular contact with customers.	4	400 and over
Maintenance engineer	Determines the causes of breakdowns and carries out any needed repairs. Regularly undertakes preventive maintenance.		
A Level	Same duties in small configurations (mini-computers, terminals, etc.).	3	350
B Level	Same duties for more complex configurations. Both posts require considerable experience.	4	500
Systems programmer	Sees that the best use is made of the operating system supplied by the manufacturer to the user. Assists the other programmers and helps to prepare operating instructions. Practical experience of console operation.	3 (plus experience)	350
Systems engineer	Fully conversant with programming, design of the operating systems and computer structure. Advises systems designers and analysts and trains operators.	4	550
Computer engineer	Conversant with all computer techniques (languages, operating systems and compilers). Capable of using real time, multi-programming and teleprocessing techniques. This is a highly technical post which requires considerable experience.	4	600

.../

Name of Post (1)	Job Description (2)	Level of Training (3)	(4)
Audit management consultant	Knowledge of business management and organisation. Thorough by trained in data-processing (hardware and software). Prepares studies prior to computer installation and use. Supervises the preparation of specifications. Works outside the firm.	4	700 and over

. Since programming jobs are tending to decrease, "Programming Institutes" should change their title and/or the content of their training.

. Manufacturers and users should co-operate more closely in training ordinaticians.

. The lack of any overall policy in the firm often creates a gap between technological possibilities and applications, and leads to overstaffing. Since the general attitude is moreover changing from one of euphoria to strict cost accounting, the sometimes long waiting period before the educational system responds should be cut down so that supply can be adjusted to demand.

. The existence of multinational enterprises, the setting up of "Computerised Europe", the gradual shift towards sophisticated technology should promote the introduction of a type of modular instruction common to all countries, with internationally standardised curricula and terminal diplomas.

We may easily quote from:

Professor Finerman:

"In most countries, educational activities in computing usually lag behind those of the United States because of the restrictions imposed by academic structures and attitudes."

Professor Teichroew:

"Large surpluses in supply are to be expected. For instance, in the United States 170,000 people are trained annually in programming. For the population of 560,000 concerned this would involve a new entry rate of 30 per cent whereas demand for programmers is about 13 per cent."

Professor Hebenstreit:

1. "It is more important to train teachers than to subsidise the use of equipment."
2. "Excellent students are being trained at present but they are only students."

318

Table 1

BELIEFS ABOUT CURRENT USES OF COMPUTERS

Per cent that believe each item is done with computers

	Total (1,001)	Sex		Age			Education		Income	
		Male (492)	Female (509)	Under 35 (456)	35-49 (276)	50 or over (269)	High School or less (534)	College or more (462)	Under $10,000 (465)	$10,000 or over (441)
Credit card billing systems	96	96	97	98	97	94	95	98	96	98
Preparing bank statements	95	95	95	95	94	96	93	97	93	98
Compiling information files on U.S. citizens	91	92	90	94	88	87	88	94	89	93
Airplane traffic control	89	91	87	91	89	86	87	91	87	92
Vote counting	88	88	89	91	90	84	87	90	87	89
Public opinion polling	81	78	85	82	84	78	78	85	77	86
Automatic control of factory machinery	80	87	72	83	80	74	77	83	77	83
Medical diagnoses	78	83	74	81	80	71	72	86	73	84
Keeping track of criminals	78	83	74	83	78	71	73	84	74	82
Weather forecasting	69	74	65	76	64	63	67	71	69	68
Sending mail advertisements to the home	69	71	66	72	70	62	65	73	66	72
Teaching children in school	64	66	62	72	64	49	57	71	59	68
Surveillance of activist or radical groups	54	59	49	55	51	54	49	59	51	55

Table 2

BELIEFS ABOUT INCREASED USAGE OF COMPUTERS BY SEX, AGE AND SOCIO-ECONOMIC STATUS

Per cent who believe computer usage should be increased

		Sex		Age			Education		Income	
	Total (1,001)	Male (492)	Female (509)	Under 35 (456)	35-49 (276)	50 or over (269)	High School or less (534)	College or more (462)	Under $10,000 (469)	$10,000 or over (441)
Keeping track of criminals	78	79	78	74	82	83	79	78	80	78
Gathering and analysing census data	70	72	69	70	70	71	67	75	68	74
Medical diagnoses	74	81	67	75	78	68	67	82	68	81
Guidance of missiles for national defense	71	75	67	64	79	74	73	68	68	75
Vote counting	66	69	64	62	71	70	63	71	63	69
Credit card billing systems	52	54	50	52	49	55	50	54	53	52
Surveillance of activist or radical groups	56	59	53	47	62	65	62	49	58	54
Automatic control of factory machinery	53	62	44	53	53	54	49	59	49	58
Credit card reference checks	52	55	49	50	49	59	53	52	55	52
Projection of election results based on early voting returns	50	44	55	49	47	54	53	46	53	46
Public opinion polling	47	47	47	47	47	47	45	49	47	49
Compiling information of U.S. citizens	50	47	53	47	55	51	56	44	52	49
Teaching children in school	48	51	45	54	45	43	46	51	45	53
Matching of people for dating	14	16	12	16	12	12	16	12	15	12
Sending mail advertisements to the home	16	19	13	15	16	16	19	12	17	15

Table 3

BELIEFS ABOUT COMPUTERS

Per Cent Who Agree

	Total (1,001)	Sex		Age			Education		Income	
		Male (492)	Female (509)	Under 35 (456)	35-49 (276)	50 or over (269)	High School or less (534)	College or more (462)	Under $10,000 (469)	$10,000 or over (441)
Uses of computers are affecting the lives of all of us	91	91	90	93	94	84	86	96	87	94
Today we can do many things that would be impossible without computers	87	87	86	90	86	83	85	89	83	91
"Computer Mistakes" are really mistakes made by people who use computers	81	84	77	81	77	84	79	83	81	83
Companies frequently blame computers for mistakes made by their own people	77	78	75	76	75	80	76	78	77	77
Computers have helped increase the quality of products and services	68	72	64	73	67	60	64	74	67	71
Computers are helping to raise the standard of living	65	72	58	67	63	63	61	70	62	68
Without the computer, American business would be in serious trouble	60	62	57	64	56	57	56	64	56	63
Computers only make mistakes when people give them the wrong information	59	63	55	59	57	61	56	63	57	64
People are becoming too dependent on computers	55	54	56	53	54	58	62	46	59	50
Computers make it easier to get credit	48	50	45	49	44	49	48	47	47	47

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Table 3

BELIEFS ABOUT COMPUTERS

Per Cent Who Agree

(Continued)

	Total (1,001)	Sex		Age			Education		Income	
		Male (492)	Female (509)	Under 35 (456)	35-49 (276)	50 or over (269)	High School or less (534)	College or more (462)	Under $10,000 (469)	$10,000 or over (441)
Computers are dehumanising people and turning them into "numbers"	54	51	57	53	54	57	58	49	57	49
Computers are more reliable than people	49	52	45	49	44	54	47	51	47	50
Computers often make mistakes when processing bills	47	43	52	47	43	51	49	44	51	41
Computer systems break down frequently	37	32	43	34	34	47	38	36	42	32
It is very difficult to correct computer errors	39	36	42	36	35	49	41	37	38	39
Computers create more jobs than they eliminate	36	41	31	37	37	32	29	43	32	40
Computers represent a real threat to people's privacy	38	37	40	31	46	43	38	39	38	36
Computers are changing our lives too rapidly	35	30	41	32	35	42	43	27	41	29
Computers can produce results which are more accurate than the information they are given	30	31	30	34	24	31	36	24	34	26
Computers always give accurate information	20	24	15	19	19	23	22	18	23	16
Computers can think for themselves	12	10	13	9	11	17	14	9	14	9

Table 4

BELIEFS ABOUT JOBS IN THE COMPUTER FIELD BY SEX, AGE AND SOCIO-ECONOMIC STATUS

Per Cent That Believe Each Item is True

		Sex		Age			Education		Income	
	Total (1,001)	Male (492)	Female (509)	Under 35 (456)	35-49 (276)	50 or over (269)	High School or less (534)	College or more (462)	Under $10,000 (469)	$10,000 or over (441)
Good for women	87	87	87	88	88	86	87	88	86	89
Offers good opportunities for high level professional people and scientists	81	81	81	82	80	79	84	78	85	78
Interesting	80	82	79	80	79	81	83	78	84	78
High salaries	72	67	77	75	69	71	77	67	76	69
Challenging for very smart people	75	76	74	74	73	80	75	76	77	75
Secure	73	72	74	71	75	73	76	70	75	71
Can advance rapidly	67	67	67	69	66	64	69	64	69	68
Good fringe benefits	61	61	62	62	61	61	64	58	64	59
Requires lots of training	71	73	69	66	71	78	75	66	74	67
Creative	60	67	53	60	59	61	63	57	62	59
Exciting	52	52	51	49	53	54	55	48	55	49
Requires mechanical ability	52	53	52	47	52	61	58	45	57	47
Long hours	25	28	22	25	26	24	25	25	25	25

II

COMPUTER SCIENCE AND THE QUALITY OF FUTURE COMPUTER SPECIALISTS' EDUCATION

by
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COMPUTER SCIENCE AS A DISCIPLINE

Arguing about computer specialists' education is of no use if it does not take place within the proper context of a common understanding of what we mean by the term "computer science" (or its synonym "informatics"). Let me suggest a definition:

Computer science is the discipline which deals with:
- the representation,
- the actualisation,
- the properties, and
- the construction

of algorithms with special regard to their processing by machines.

This definition, at first sight, may appear as a very narrow one. But it is not. Let me expand a little on the four points mentioned:

First let me talk about things covered by the term representation. There are three subpoints:

Subpoint 1:

This covers technical aspects of languages,
such as syntax,
semantics,
pragmatics,

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1) Lecture given at the OECD on 6th October, 1972.

i.e. it covers all aspects of formal languages and of algorithmic languages. It is concerned with the knowledge about processing languages and programmes mechanically.

Subpoint 2:

These are kinds of psychomechanical aspects which I can describe only by examples. Let me give two very short ones:
Example 1: There is the good rule that the intuitive meaning of a sequence of symbols in a programme should also constitute the semantics of this piece of text, e.g. the sequence

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should not mean division of the variable 5 by the floating point number one, etc., instead of its intuitive meaning. One could call this the rule of immediate comprehension.
Example 2: Another good rule is that simple syntactic constructions should correspond to simple semantic situations; complicated syntactic constructions should correspond to complicated semantic situations.
Following this rule one gets an immediate feeling for the complexity of the programme one is writing. One could call this rule the rule of natural mapping of mental processes in programming.
This area is one of the most neglected by language designers.

Subpoint 3:

This point has some connection with the previous one. It deals with what nowadays is called structured programming: language elements should be structured in such a way that programmes are automatically more intelligible without much further explanation. I think here of the work of people like Dijkstra, Hoare, Wirth and others. It is the most powerful and promising approach to the testing problem known thus far. It is a nontrivial version of the paradoxical sentence, that programmes are error-free if, and only if, they are written correctly from the very beginning.

So much about representation of algorithms. "Representation", looked at it this way, is a wide field in itself. Languages determine the rails of algorithmic thinking. The inclusion or exclusion of a certain language function may decide the fate of an application area for the next 10 years! (Example: ALGOL 60 and string handling in Europe during the sixties).

Let me talk now about things covered by the term actualisation. Again, three subpoints should be mentioned for illustration:

Subpoint 1:

This covers the area of how to subdivide the functional unit called computing system into hardware and software building blocks and all the trade-offs involved in such a process.

Subpoint 2:

This is the area of how to choose primitive programming functions as a basis for the build-up which takes place in each programme, e.g. how to choose an instruction set. Of course, the same is true for microprogramming.

Subpoint 3:

In order to get a programme executed it has to be embedded in a certain functional environment. Therefore determining the function sets of general purpose operating systems and of special application systems is an important field which, moreover, must always be viewed with regard to the continuation of these functions into the surrounding human organisation.

What is meant by the term properties of algorithms I want to sketch by means of another three subpoints:

Subpoint 1:

This covers the area of determining the dynamic behaviour of programmes with respect to I/O, memory, instructions used, etc. It has to do with the efficiency of execution, memory-time tradeoffs, frequency of use of resources, etc. It is also, on the practical side, the area of measurement techniques and tools.

Subpoint 2:

This has to do with requirements stemming from subpoint 1 for better languages; for instance, a good language should allow the determination of dynamic properties by a static inspection of the programme text.

Subpoint 3:

This deals with inner properties of an algorithm, e.g. the possibility of rewriting a programme in such a way that the essence of the algorithm is preserved while a more parallel fashion of execution takes place. Similarly, one could identify natural checkpoint-restart properties of a programme.

Finally I am going to mention some areas covered by the term construction.

Subpoint 1:

It comprises all technical and managerial aspects of programme construction, e.g.

- choosing a language, or, if necessary, even making one before starting; and
- stepwise programme construction after identification of the functions needed; and
- verification of the correctness of the programme by careful testing; and
- optimising a programme by applying rules like "... have the function as far inward as necessary and as far outward as possible ..."; and
- covering special problems with very large systems with many functions, and construction support systems, etc.

Subpoint 2:

It has to do with environment interrelations while constructing algorithms. The following issues are of importance here:

a) How to work through a new problem area such that an algorithmic solution becomes feasible at all?

b) What are the implications of the algorithmic solution for the environment? How does the situation change when the computer becomes an everyday companion in this environment?

c) What are long-range changes in life-qualities for many people as soon as the computerisation has reached a certain integration level?

This leads me to a general remark on what the application aspect of computer science is all about: it is developing and organising future organisation. This is my personal view of computer science. It is essentially an engineering discipline, because one of its primary objectives is optimisation over sets of possible realisations.

THE QUALITY OF EDUCATION

Let us now begin to talk about educational aspects. To this end let me first report on some observations which anybody can make when looking at the computer field.

First observation: It is a fact that everything around computers has to do with large quantities of all kinds of things: speed, paper, punch cards, bytes/second, people, money, etc.

Second observation: There is a rapid change of environments, equipment, techniques, people, etc.
(Observations 1 and 2 together with today's non-automated way of systems building have the consequence of an enormous reprogramming and conversion effort which is continuously ongoing.)
Third observation: Problem areas seemingly unrelated in the past can no longer be treated independently. There is a considerable integration effect.
Fourth observation: There is a wide spectrum of the ways and of the frequency of using algorithms: from being tried only once (and perhaps never used for production) on the one end, to intensive use of an algorithm over years on the other. In most cases the algorithms are complicated rather than simple.
Fifth observation: Each regularly used programme seems to need some degree of maintenance, either because of old errors or for the sake of (so-called) "slight" functional changes.

The author believes that the change in the human scene by computers will be greater than by any other human invention in the past.

These observations outline (roughly) the quantity and the quality of the people needed in this field. The ideal man needed must:

a) have excellent knowledge of one or more problem areas, besides his knowledge proper about computer science topics; and
b) see implications, interdependencies, constraints, far-reaching consequences in human organisations; and
c) himself have programming skill like a music composer; and
d) be resourceful; and
e) be very good in communicating and cooperating with many other people, i.e. ideal for teamwork; and
f) have a well-balanced attitude towards efficiency.

This is the "superman" many institutions are watching out for so that he can solve their organisation mess (which was brought into the open when they set out for the "automation"). What we can justly ask from the computer specialist is, of course, that he contributes towards solving these problems.

UNIVERSITY OUTPUT AND COMPUTER SALES

How can our educational institutions provide for such top people in such large quantities? Do we really need so many of them so well educated? (The author tends to answer the last question with an unconditional "yes".)

Our standard European universities (when they have "completed" their internal staff and teaching material selection) have a certain output rate which, per "big" university, will be roughly 100-200 people/year. These people will not be of the kind described above, but they will be educated with this ideal in mind. Perhaps 5 graduates per university and year may actually come close to the ideal. On the other hand there is the rapid dissemination of computers over our countries which will necessitate the employment of a multiple of the number of people the universities can produce.

There is the well-known migration or diffusion of employees of completely different and unrelated professions (e.g. bakers, truck-drivers, butchers, secretaries, salesgirls, etc.) into the computer environment. Often they are encouraged to do so by irresponsible private schools and companies. They start with a career as an operator, become (after some time) organisers or "applications or systems programmers" and, again, after some time, play an important role in decisions which may influence the environment of thousands of people, without ever having had a sound education even slightly resembling the contents of lectures adequate to cope with the above-mentioned objectives. (Example: Such "systems programmers" in the public administration influencing the format and the contents of the personal identification keys in an information system covering all people of a nation. Their "advice" producing the usually poorly made billing systems of public and business bodies of all kinds.) It is estimated that the ratio of well-trained personnel to such "underground experts" is 1:8 to 1:10 in most countries with high computerisation. Because of the expected output rates of the universities on the one side and the ever increasing sales in computers on the other, this ratio will become worse (with all consequences of this tendency). In the United States the number of these "unwashed programmers" is estimated to amount currently to 350,000.(1)

All educational efforts must be viewed with regard to this situation. We are overwhelmed by the mechanics of computer sales with no chance of a short-range cure. There is only a slight hope in the long run, based on the following assumption:

> In the future all kinds of systems may in the end be generated more or less automatically with more safety, ease of the testing problem, a much shorter development cycle, more possibilities for experimentation, etc., as consequences. This will increase the influence of the well-educated people and at the same time get a large part of the unwashed programmers into their proper activity area: parameter supply and observation.

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1) T. Steel, IFIP-Conference, Zakopane, September, 1972.

SOME OBSERVATIONS IN THE EDUCATIONAL FIELD

University education will produce two kinds of people:

a) computer science majors with a minor degree in an application area,

b) application area majors with a minor degree in computer science.

Application areas are, e.g. physics, chemistry, business administrations, law,medicine, etc. The education in computer science will have to emphasise flexibility, resourcefulness, ability quickly to understand a problem, to apply general principles in the proper way over detail knowledge, without however neglecting it.

Currently many computer scientists still have to fight their way within inadequate mathematics or electrical engineering departments, where traditionally the importance and the implications of programming are grossly underestimated. As a consequence most universities are at present unable to offer enough practice oriented courses.

Polytechnic institutes and private schools are in danger of offering too much vocational training. They tend to favour the details of today over the long-lasting principles. The output of these schools consists of people who are rather immobile. These people will have a much harder stand in this rapidly changing field. A considerable upgrading of the quality of the education at this level is necessary.

The situation is even worse with the "education" offered by some companies. To quote a well-known computer scientist, their "contribution" has to be viewed just as a disgrace to culture.

III

WHO MUST ASSURE THE TRAINING - PUBLIC AUTHORITIES, PRIVATE INSTITUTIONS OR MANUFACTURERS?

by
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We are all aware of the huge development of computers in the last decade, the growth rate between 1960 and 1970 frequently reaching and sometimes exceeding an annual 25 per cent. Although it has slowed down since the onset of the 1970s, as a rule it still stands at over 15 per cent per year. This marked expansion has created corresponding training needs. A brief history of the development of computer utilisation is necessary in order to show what form these needs sometimes take.

The first computers worthy of the name originated during the Second World War for the purpose of calculating complex missile trajectories, the computer being designed as a gigantic "calculating machine" for performing scientific calculations. The large-scale computers manufactured by UNIVAC, CDC, etc., are almost in the direct line of descent, but can be used for many purposes other than scientific calculation. IBM computers are the result of a somewhat different approach as by the 1950s the IBM Corporation, specialising in office equipment, foresaw the enormous development of computer utilisation in management (at present three-fourths of computers installed are used for management). Thus the computer is not merely a calculator, but a logical machine capable of processing chains of characters by means of pre-recorded programmes. This observation is the key to most of IBM's commercial growth and much of computer development. To promote its continued expansion, the majority of computer manufacturers had to set up extensive training services for their customers.

Realisation of the existence of the "science of information processing" as distinct from "computer science" is much more recent.

The French word "informatique", coined in 1957 by Perret, rapidly became established in France (it was defined by the Académie française in April 1966) but until recently was slow to gain any ground in other countries. Of late, however, informatics is a word which has come to be widely used in English-speaking countries.

At the same time, the computer and the modern sorcerers who taught these wonderful and costly machines the power of speech were acquiring a legendary aura. To be a computer expert seemed to be an "open sesame" to the future; the resulting fascinating appeal of the profession was to be vastly exploited by certain private enterprises, some specialising in the sale of computer courses, while others rather dealt in pipe dreams. The authorities concerned themselves with the kind of demand which was taking shape, and when the Sixth Plan (1971-75) was being prepared in France a Commission d'étude des besoins de formation en informaticiens (Commission on Computer Manpower Training Needs) was set up.

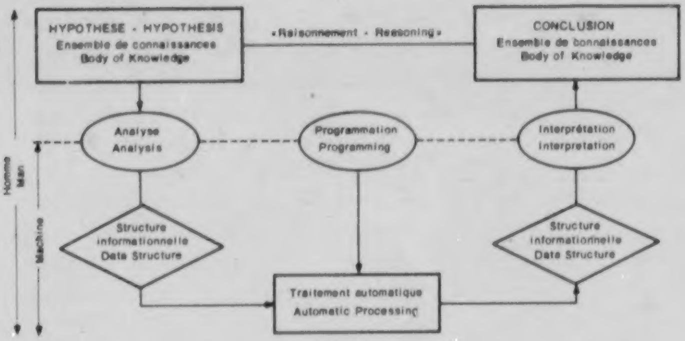
The role played by computer manufacturers in the development of information processing, the very real increase in demand, and advertising campaigns of private firms, raise the question of where the responsibility for computer manpower training should lie - with the government, with private institutions or with manufacturers. The reply, which must naturally be qualified, is one we shall now try to enlarge upon. A first point which must again be urged is the distinction between computer science and information processing (much like the difference between the science of telescopes and astronomy). To emphasise this difference, the Commission referred to above changed its name in the course of its work, calling itself the "Commission d'étude des besoins de formation en informatique" (Commission on Information Processing Training Needs), thus bringing out the difference between the mere need for staff to look after the machines and the general need for training in all the spheres where information processing is used.

To discover who should be responsible for such training, we must try to define the nature of the instruction required. The importance in modern times of information processing suggests that it extends far beyond mere economics, and its significance has indeed been compared to that of printing. The twentieth century, instead of being called the automobile age, one already changing our way of life, might well be regarded as the age of the computer, or one revolutionising our way of thinking.

To understand the phenomenon it is well to revert to the very nature of information processing by citing one of the best definitions of the French word "informatique", which is that of the French Academy: "... the science of the rational processing, particularly by automatic machines, of information regarded as a knowledge and communication medium in the technical, economic and social fields". This definition makes a now classical distinction between semantics and syntax: information is the medium for conveying knowledge and for communication independently of their meaning. One of the most traditional media is the written language, which takes the form of alphabetic and numerical symbols, punctuation marks and spaces, etc. The purpose of information processing is to manipulate these symbols (syntax), e.g. by arranging them in alphabetical order, putting them into the "plural" by adding a suffix to each "word", etc, independently of their meaning (semantics).

In short, "the information processing approach" is comparable to the normal mental process (Fig.1) which consists in passing from one body of knowledge called "hypothesis" to another called "conclusion". The process leading from hypothesis to conclusion, known as "reasoning", brings logic, imagination, intuition, analogy, etc. into play. "Reasoning" closely blends semantics (knowledge itself) and syntax (manipulation of the knowledge medium). Thus, for instance, the process leading from such a hypothesis as existence of the telephone and telephone book to such a conclusion as the correct time of day consists in looking up a series of characters in the book (telephone number) associated with another series of characters ("time service"), and dialling the series on the telephone. Since the dual operation of looking up the characters and dialling is entirely independent of the characters' meaning, it could be carried out by an automatic device.

Figure 1


HYPOTHESE - HYPOTHESIS
Ensemble de connaissances
Body of Knowledge
«Raisonnement - Reasoning»
CONCLUSION
Ensemble de connaissances
Body of Knowledge
Homme
Man
Machine
Analyse
Analysis
Programmation
Programming
Interprétation
Interpretation
Structure
informationnelle
Data Structure
Traitement automatique
Automatic Processing
Structure
informationnelle
Data Structure

Information processing precisely consists in systematically identifying anything in the traditional reasoning process which simply calls for the manipulation of symbols (syntax) and, if necessary, entrusting the latter operation to an automatic device (a computer) which is "programmed" to yield some desired result; the machine deals with "data structures" whose meaning (semantics) is unimportant.

It will therefore be seen that information processing in this form is of far greater general scope and cultural value than any mere computer manipulation. It means that a process is available which has the advantage of being more objective than any ordinary mental approach and which can become a very powerful tool if it is associated with suitable data processing methods. It will also be realised that it can be used so many ways as to include almost all human activities, i.e. those making use of a knowledge medium. In this sense information processing is comparable to the art of printing, which broadens, complements and extends.

This analysis therefore shows that any systematic association of the computer with information processing should be avoided, and that the latter should even less be defined in computer terms. While invention of the computer has revealed the existence of information processing which has thus been given its real dimension, the computer is in no way an essential component. Although information processing courses should hence not disregard the machine's existence, they must go further if they are to deal with the cultural and practical aspects of the subject: in future everyone will have to be aware that information is indeed processed, even if everyone does not happen to process it himself. Similarly, an increasing number of occupational activities will come into contact with information processing, when it will have to be used even if computers are not handled directly; finally, more and more computer specialists will naturally be required to use, and above all use efficiently, (i.e. "rationally" according to the Académie française definition) as well as design, ever more sophisticated computers in ever greater numbers.

Three types of training are therefore required:

a) Public awareness. This consists in teaching the public that it exists, what it is used for, what it can do, what its limitations and dangers are, what the role of computers is and what jobs are connected with information processing. It is part of the general education of a modern country's future citizens.

b) Initiation. This means teaching anyone whose work calls for the processing of information enough about the use of such a tool without however going into any great detail. The persons so initiated must be able to use information processing as they would a telephone and to supplement their knowledge should recourse to some specific information technique be needed.

c) Specialisation. This consists in training persons whose main occupation will have to do with information processing. It is this need which is most directly computer-oriented and most commonly perceived: the goal is to be an analyst programmer, console operator or in short a "computer specialist".

It should, however, here be noted that computer specialist training is bound to become steadily broader. Rapid technological change increasingly calls for general education; similarly, the many new uses of information processing require training in some additional field, such as in organisation for business management, in medicine for medical applications and in teaching theory for educational purposes, etc. The numbers of "pure" computer specialists will decrease and will be employed mainly by computer manufacturers and in computer research laboratories.

A rather obvious but striking illustration of such levels of training may not be amiss. Information processing can be likened to the use of a hammer. Public awareness consists in finding out that a tool called a hammer exists, that it can be used for such various purposes as clinching, hammering, and driving nails but not screws; that there is a danger of hitting one's fingers, and that if the purpose is to practise some trade where a hammer is used the right sort of training can be obtained. Initiation consists in teaching the rudiments to anyone who may have to use a hammer, for instance, how to drive a nail into a wall in order to hang a picture. Specialisation is training for some trade in which the hammer is used as the principal tool, such as carpentry and joinery, etc., generally calling for other types of knowledge. Finally there might conceivably be "pure" hammer specialists, e.g. theorists making a study of the most suitable form for some particular use.

The various types of training for information processing having thus been defined, an attempt can now be made to determine where the responsibility for training should lie.

From a general standpoint the answer seems fairly clear: when seen as a whole, with a cultural and social role to play, information processing is primarily something which must be taught by the authorities. This does not mean, of course, that it should be the monopoly of public education. It will thus be well to review what can or should be done by computer manufacturers and private institutions.

We have already mentioned the enormous training effort achieved by the manufacturers. While they have certainly done pioneer work, they have also had the commercial aim of promoting products, creating needs among potential customers (briefing or initiation courses for managerial staff) or enabling such needs to be promptly met (training courses for the customer's own employees). The cost of this service is, of course, growing considerably and manufacturers are increasingly inclined to charge for it, thus themselves setting up a market for computer manpower training. Leading manufacturers would most certainly like the authorities to take over the bulk of computer training since they feel that they are not equipped for the task and seldom have the means of carrying it out in view of all it implies. Just as motor manufacturers are unwilling to train motorists or prepare the ground for the automobile society, so are computer manufacturers reluctant to train information specialists or pave the way for a society in which information processing will play a major role. This they do not want because they well know that information processing is not synonymous with computer science and that just as a person changes from some make of car to another he can also change to another make of computer. There is only one type of training that manufacturers should continue to provide: that directly connected with the computer equipment itself, i.e. of staff directly involved with the machine (console operators) and carrying out technical and commercial tasks for the manufacturer himself (design, operation, sales, installation, maintenance, etc.).

What should the role of private institutions be? This question immediately brings to mind the exaggerated claims made during these last few years by various firms selling empty promises rather than any serious computer training course to the public. ("Become a programmer in three weeks" was the slogan used in certain advertisements). Yet these claims should not hide the honest efforts of certain enterprises, such as consultant firms on the subject (*sociétés de conseil en informatique*). We have already noted that certain manufacturers, notably IBM, are likely to charge for training separately, over and above their equipment. This has created a training market which the consultant firms are rightly exploiting by offering to provide a more "personalised" service than the manufacturers do. It may be pointed out that unlike that given by private enterprises this sort of instruction is more closely akin to continuous than basic training.

It is in the matter of basic training that the authorities have the largest part to play. Awakening responsiveness, which is a general form of education designed for the future citizens of a modern country, mainly takes place at secondary-school level. While some action may be envisaged in primary school, and while it should also be a part of continuing education, most of it belongs at general secondary level. Action of this type has been undertaken in various countries, and it may be well to record that of the French Ministry of Education, which introduced information processing to a number of teachers from every discipline in general secondary education; a noteworthy point is that manufacturers contributed to such a retraining project by providing the relevant courses during the first year (1970/1971): after training for one school year or by correspondence the teachers then help to prepare examples showing the use of data processing in their own subject; they try out the examples in their classes and some teachers are able to illustrate them on mini-computers set up in a few lycées for educational purposes.

Introductory courses also belong in public education. Whenever they supplement other forms of training they should thus be provided with all such types of instruction as provided by the educational system.

If the courses prepare students for some profession, then they generally come under higher education (which is the ideal level for introductory courses in information processing). Yet secondary education, insofar as it provides occupational training, also has an initiatory role to play: an example is training people for jobs in the services sector and an introductory course in the art of capturing, handling and retrieving data will become increasingly important. In continuing education, the rudiments of information processing should also be a part of most pre-professional courses.

Finally, specialisation in information processing of course has its place in public education. Training for the senior computer specialist grades (analysts, systems designers, engineers and project leaders) properly belongs in higher education and that for operative staff (programmers, etc.) in secondary education. But in this type of training more than others, constant technological change requires a general form of education as a complement to specialisation, one which cannot easily be provided as part of the basic training obtainable in private institutions. In continuing education, however, this aspect may be of secondary importance and private institutions may be better equipped to take a hand. Yet even in continuing education the authorities cannot altogether neglect their responsibilities and, even if they do not provide every requisite facility, they should supply a number of pilot courses which can be used as models and if necessary help to raise the standard of the training market.

Finally, the authorities may be said to have a basic training role to play in information processing. After all, from this standpoint it is not a subject in any class by itself, a conclusion which need cause no surprise when it is realised that information processing is not computer science and its cultural role is understood. What the manufacturers' task will then be is to deal with matters directly concerned with equipment and sales. Private institutions should perform their normal duties, especially as regards continuous training, although the authorities will have to take steps to upgrade the market and set the standards for it.

IV

WHO MUST ASSURE THE TRAINING - PUBLIC AUTHORITIES, PRIVATE INSTITUTIONS OR MANUFACTURERS?

by

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During the last two decades we have seen a very rapid growth in the usage of electronic data processing equipment and in the usage of communications equipment. In recent years the use of the two together in the same system has become increasingly common. In the early years of computers and computer science the percentage of the population affected by them was very small and as a consequence all aspects of their use, including training and education of computer specialists, was a matter of relatively small concern to most people.

With the recent rapid expansion of the industry and the application of computer technology to so many new fields there has come an increased public awareness of its importance in business, in science and in society as a whole. The importance of this industry is now such that the attention of those who have been responsible for manpower training in the past, namely the manufacturers, the users, the private educational institutions and the public authorities, should be focused on the question of how best to ensure adequate and efficient training in the future. Perhaps the time has come to determine areas of responsibility among the four principal groups that will provide such training and education. The author of this paper will view the question from the point of view of the manufacturer but will of course also discuss the roles of the other three groups as well, but as seen from the point of view of the manufacturer.

In the very early days of electronic computers most of the training of computer manpower was done by the manufacturer of the equipment and often on the premises of the manufacturer. In those days when programmes were written in machine language, an understanding of the inner workings of the particular computer was as important to solving a problem as was an understanding of the algorithm for the problem solution. As the number of computers in use grew, the need for specialised training of course also grew and much of the training of computer manpower moved to the user organisation, but always with strong assistance from the manufacturer.

Until recently computer training or training in the use of computers in the university was confined to a single department of computer science or to another department responsible for the computing centre - often the mathematics department. However in very recent years there has been a trend toward making use of the computer for problem solving in many departments. Students in these various departments do not necessarily become computer scientists in the traditional sense but learn how to apply the computer to the solution of problems in their field of interest. This has become increasingly practical with the advent of problem oriented languages rather than machine oriented languages. Another big factor has been the evolution of systems, including remote terminals, which permit interactive time-sharing computing.

I believe this kind of expanded use of the computer into all or nearly all disciplines in a university will continue to grow. There will continue to be a need for the computer science department to train the real computer specialist who understands computer hardware and operating systems. However there will be the much greater need to train much larger number of students how to use the computer as a tool to solve their particular problems but without the necessity of becoming computer scientists.

Analogous with the above trends in universities will, I believe, for the same reasons be a trend toward much wider use of the computer in all industries. Each company will have its computing centre with its own computer scientists who understand the hardware and operating systems, but throughout the organisation will be users at terminals who are interested only in problem solving and who probably learned their techniques and methods in the university. Indeed this arrangement exists now in a number of companies.

Another important factor in the changing nature of training is the rising importance of computer assisted learning. Several universities in the United States, e.g. University of Illinois and Stanford University, have had remarkably great success with this method of learning. If this sort of success becomes more generally realised the impact on education could be important.

Since methods of training is not the subject of this paper I shall not pursue the question of computer assisted learning any further. However I should mention that two other factors in the changing nature of training are of considerable importance. One of these is more complete and better organised use of libraries. Systems are in use for retrieving references and material about a given subject through terminals remote from the library. Another important factor is the movement of computer training into lower age groups. Until recently very few primary and secondary schools were offering any training in this field. However the number will almost certainly grow and it is made possible through the development of better and cheaper computer terminals and their use in computer assisted learning.

In the light of what we know today we might ask ourselves what will the training and education of the future be like. There will continue to be at least five main groups to be trained.

1) The computer user in industry.
2) The computer scientist (or computer professional) whether he be in industry or in a university.
3) The university student and faculty as users.
4) The primary and secondary school student and faculty as users.
5) The computer operator.

There are clearly a number of other groups one could name, such as the handicapped, the disadvantaged, the prisoners and the adult students. However, I believe that from the point of view of numbers of people affected the five groups above represent the majority of people to be trained.

I now come to the main point of this paper - namely to the question of who should be responsible for providing the training or education for the above groups of people. I shall defer discussion of the role of the manufacturer until last but that is the role to which I shall give most emphasis.

In most countries the public authorities (Department of Education for example) are responsible for ensuring appropriate education in the primary and secondary schools and in some cases colleges and universities. It has become clear that a part of that education should be training in the use of data processing or computing equipment for problem solving or more generally for achieving objectives. Industry, including computer manufacturers and various foundations, can and should provide assistance in this education process in the form of grants or other financial assistance. Also they may provide assistance in the form of teaching staff on a part-time basis or on a sabbatical leave. However, since the primary responsibility for education in this group rests with the public authorities it follows that the primary responsibility for their computer education will also remain with the public authorities. It is probably primary and secondary education that will be most affected by computer assisted learning. This is true in part because the educational material at this level is more structured and therefore more easily adapted to a previously prepared learning programme. It is also due in part to the greater need here because of the larger number of students and the greater shortage of qualified teachers at this level.

The development work for computer assisted learning should certainly be carried out in part at the instigation of the public authorities. In Canada this seems to be the main driving force behind this development work. However others, including private institutions such as private universities, and manufacturers, should play an important role in the development of this new approach to education. In the United States, in Europe and in Japan a fair number of universities are experimenting with computer assisted learning methods with some significant success. In addition, several manufacturers are also carrying out experiments with this method of education within their own organisations and sometimes in co-operation with a university or a secondary school.

The universities, whether public or private, have played an important role in computer education from the beginning. And this will and should continue to be so. After all, the university is responsible for the total education of its students and clearly this includes computer education. The concern of most universities will be mainly that of how best to use computers to solve problems and achieve objectives. However, there will doubtless continue to be a number of universities with a group of students and faculty concerned about computer science in the traditional sense - computer design, programming, language design and operating system design. And this should be so because they will thus influence the design of systems in industry and will also provide a source of new people and fresh ideas to industry. Therefore the universities should, in the interest of useful education, strive to attain at least two main objectives in the field of computer training. First, they should endeavour to ensure that students in all fields receive instruction in how best to solve the problems or achieve the objectives in that field. Often the computer will prove to be a useful means for achieving these needs. And when this is the case the university should make sure that the fact is brought to the attention of the student and that he is encouraged to use the computer in the best possible way to meet his needs. The emphasis here should be on getting the job done and, where useful, the computer should be worked into the process in the most natural way by the student with the guidance of his teacher. This, of course, requires that the teacher be well versed in the use of the computer to assist in achieving the course objectives. Secondly, the university should provide a sequence of courses in computer science which will permit those students who are so inclined to specialise in this technology. From this group of students will come the specialists in computer science for the various industries needing personnel to run their computing centres. Because industry benefits from the existence of computer education in universities, it is appropriate that assistance, financial and personnel, be given in a variety of ways.

It is also clear, I think, that part of the responsibility for training of computer manpower must remain with the users of computers in industry. Computer users in various industries have always received very substantial assistance from computer manufacturers in the training of their computer personnel. In the very early days practically all of this training was done by the computer manufacturer. However as requirements grew the user has assumed more and more responsibility for training his own people - especially in the use of computers for applications work.

When we speak of applications work we are referring to expertise in the use of the computer as a means of achieving the objectives of the particular mission. For example, the mission might be that of forecasting tomorrow's weather. The applications specialist in this case must be able to state the problem in a form which can be translated into a computer programme. This might include derivation of a set of equations representing the flow of the atmosphere in some slightly idealised form. It may then include approximating this set of differential equations by a set of finite difference equations and finally prescribing a method of solution of the finite difference equations using observable or verifiable information as a basis for determining changes with respect to time and thus leading to a set of future conditions.

Sometimes a substantial amount of training is necessary to prepare the individual to do the necessary work to state the problem in a form which can be directly translated into a computer programme. The amount of training necessary is of course a function of the complexity of the application. In this field the user is sometimes more capable than the manufacturer in supplying this kind of training. The manufacturer has tended to concentrate more on the training related to the computer hardware and the operating system. The decision by several computer manufacturers in the United States to price education separately has further stimulated the trend toward users of computers in industry carrying out their own computer education programmes. However, there is a danger in going too far in separating the hardware and operating system training from the application work. The computer manufacturer must maintain an understanding of the applications for which the equipment is used in order to continue to improve the design in a direction to facilitate applications work.

Nevertheless the major responsibility for computer education in the application field has passed to the user and this will most likely continue.

We come now to the role of the manufacturer of data processing equipment in computer manpower training. Education is indeed a major activity of the computer manufacturer. First of all the manufacturer must be fully responsible for the training of the company's own personnel. This in itself is a substantial task in an industry that is changing so rapidly. For example, in 1971 IBM employees in Europe spent more than 265,000 student days in formal training programmes, achieving more than 18,000 specialised course completions in the process. What is the nature of this internal education in IBM in Europe? Most of it is basic and intermediate training for relatively new salesmen and systems engineers in our marketing force. This training is designed to give them an understanding of the products IBM sells and services, and the major applications for which these products are used. Each new member of IBM's marketing force spends about 18 months undergoing training - six months receiving classroom education and the remaining year in closely supervised on-the-job training. And after fully qualifying as a member of the sales force he continues to receive a minimum of three weeks refresher education each year. Most of this education is carried out by the local IBM companies within the various countries in Europe. However, IBM also has a number of international education centres that carry on advanced education for salesmen, systems engineers, financial and administration managers, and other managers. This training ranges from one week to three months and amounted to about 50,000 student days in 1971. Most of the training discussed above is in the marketing organisation. In addition the six laboratories and six plants in Europe have extensive internal education programmes for training development engineers, manufacturing specialists and others.

In 1971 more than 100,000 technical and managerial customer personnel underwent instruction through IBM's education programmes in the latest developments in data processing for a total of 1.1 million student days. In its education programmes IBM places strong emphasis on practical work which allows the student to learn from his own experience. For example, extensive use is made of computer simulations in so-called business games which make it possible for students to see the effect of their decisions when learning about management information systems.

Self-study courses are also used in which the student can complement classroom instruction with independent study. Guided by a computer he is directed to video tapes, films and texts to learn about his chosen subject. When he feels he understands the material he returns to the computer terminal to test his knowledge. When he fully masters the subject he receives further guidance as to his next step. Otherwise, he is asked by the computer to review those areas in which he has demonstrated weakness.

Extensive use is made of closed circuit television. Installed in many of IBM's European education centres, this concept makes it possible to record outstanding lectures for frequent use in many countries. In addition it can be used to film individual participants or group action for immediate replay to allow for self-evaluation. Finally it establishes a library of visual source material for students to select so that they can study at their own pace, and at a time of their own choosing.

Apart from the rather extensive educational effort expended by a computer manufacturer in training the company's own personnel and the personnel of its customers, most manufacturers also participate in some way in the training of students in primary and secondary schools and in colleges and universities. This participation is often in the form of an educational grant or contribution in financial terms to the educational institution. This contribution may take the form of an outright grant of funds or it may involve making the computing equipment available for general educational use at a reduced price.

Another form of assistance to schools is that of providing faculty on a part-time basis to the school or in some cases putting the company's employee on a sabbatical leave for a year or more to teach at the school or university. This practice has been used in the past with reasonable frequency and seems desirable to be continued based on its success in the past.

It is clear that the computer manufacturer has always in the past played a vital and important role in providing leadership to users and to educational institutions in the application of computers or information handling systems to the solution of problems and to the achieving of objectives. Only the computer manufacturer has the total resources to keep pace with the rapidly changing technology and its possible effect on the handling of particular problems or missions. The computer manufacturer must ensure that his own personnel are trained so as to ensure continuing technological discoveries and developments. He must also ensure an excellence of training and understanding of customer problems and missions so as to take fullest advantage of technological developments in providing better equipment to meet customer needs. For this latter objective the manufacturer must rely heavily on the user for information about the user's needs and perhaps an understanding of the user's current approaches to problem solving. Just as the user must rely on the manufacturer for information about technology and equipment and programming systems, the manufacturer must rely upon the user for some of his information about uses and possible future uses. And we must not overlook the important role of the university in fundamental research in both technology and in applications work. Some very important techniques and methods for problem solving have been worked out through the joint efforts of computer manufacturers, universities and other users. An example is the method for faster computation of Fourier Transforms.

We can only conclude that all groups - universities, other users, public authorities and computer manufacturers - have an important role to play in computer training. Through working together all groups can benefit materially. But by virtue of the resources available and tremendous store of experience in both technology and applications the computer manufacturer is in an excellent position to provide continuing leadership in the whole complex field.

V

SPECIFIC TRAINING FOR MANAGEMENT

by

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INTRODUCTION

Much has been written about education and training for various functions and positions related to the computer. Conferences have been held; see, for example, Scheepmaker and Zinn (1972).(1) The number of people involved in the use of computers has steadily increased and therefore training, both formal and on-the-job, has been taking place. It would be presumptuous to attempt in this paper to summarize the literature that exists, to try to provide quantitative estimates for the number of personnel in all the categories that will be required, or to propose detailed training programs. A more reasonable aspiration is to outline some of the considerations that support the intuitively obvious view that a variety of training programs is necessary and that their content will change, and to provide some references to more detailed sources for a discussion of the factors which should be taken into account when specific educational programs are formulated.

This paper focuses on university programs for education of entry level positions into management and information systems as the most important area needing attention. The existence of effective academic programs would help to set minimum aspiration levels for continuing education and on-the-job training programs. In such programs, it is particularly important to distinguish between education for Computer Science or Informatics and education for organizational uses of computers.

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1) See References at the end of this Chapter.

USE OF COMPUTERS IN ORGANIZATIONS

Even within the limited objective established in the previous section, it is still necessary to specify more precisely the scope of computer use for which training is being considered. This section is devoted to defining the relevant area as that of the use of computers to serve organisations.

The computer - or, more broadly, electronic digital stored program machines, and their associated equipment for recording, display, storage, and communication of data - is extremely versatile and can be used for a number of quite different purposes. The appropriate training for the various uses obviously contains some common elements, but much of it should be related to the type of use. The particular area of concern in this paper is the use of the computer for "organizational" purposes, i.e., for carrying out data processing and information processing operations that are necessary for the effective functioning of the organization and that previously had to be performed manually or not at all.

There is no generally accepted name for this use of computers. The ACM Curriculum Committee on Computer Education for Management used the term "Administrative Information Systems" and gave the following description (Teichroew, 1971):

> "Administrative Information Systems (AIS) includes the functions commonly termed business data processing or commercial data processing, as well as the more exotic management information systems. All of these terms have been subject to a variety of interpretations in different contexts, and contain words which serve to perpetuate misunderstandings. The term data processing has to many the connotation of routine support functions, such as payroll preparation and transaction accounting, that are necessary for the operation of organizations but prosaic in character. By contrast, the term management information systems conjures up a vision of vice-presidents gathering information and transmitting decisions through individual, remote consoles, a vision which has caused the term to assume some disrepute among those concerned with the world as it is. Administrative Information Systems are not restricted to business or commercial organizations in the sense of profit seeking enterprises, since similar functions are required in the operation of organizations such as hospitals, schools, libraries, research laboratories, and government agencies."

It is unlikely that any one name will be universally recognised in the near future. Therefore, it is not too important whether the term used is Administrative Information Systems, Management Information Systems, or Management Informatics; what is important is that

57

this use be distinguished from Engineering and Science uses, frequently called Computer Science or Informatics, and Problem Solving use, usually called Artificial Intelligence.

Education for organizational use must focus on organizational purposes. The conventional wisdom is that while computers have been effective in routine data processing, they have not to any significant extent been used by the managers or affected the way a manager operates. While this is true, it is also true that computers have had a considerable impact on the "management" of organizations. The distinction between managers as individuals and the management process is an important one to make in planning educational programs. The following example from the position paper mentioned earlier (Teichroew, 1971) outlines the gradual expansion of information processing performed by computer based systems.

> "The procedures used in early business data processing systems were very simple. Computerized systems duplicated existing manual and punch card systems and made little use of the power of computers. In recent years, these procedures have become much more complex, along with the parallel development of more complex information processing technology.
>
> " As an illustration of the evolution of information processing systems, consider inventory control. Most early computerized inventory control systems required one file with one record for each part containing data on quantity-on-hand, unit price, etc. Daily transactions consisted of orders requiring items to be removed from inventory and receipts resulting in items being added to inventory.
>
> "A second level of sophistication was reached when automatic reorder levels were added. Cost and usage data were added to the file and a procedure developed to determine when a reorder was necessary. The system produced an additional output - instructions to the purchasing department to acquire additional items.
>
> "A third level of sophistication resulted from adding automatic vendor selection, intended to reduce delays in manual production of purchase orders. This required that the inventory file show which vendors could supply each part. Since many parts could be purchased from several vendors and most vendors supplied several parts, a second file was added to the system containing constant information for each vendor. An efficient technique had to be developed for referencing and retrieving a particular vendor's record.
>
> "A fourth level of sophistication arose with requirements such as minimization of transportation costs. Since transportation costs frequently depend on shipping in carload lots, a model

must be added to the system which determines what other parts could also be ordered at this time to fill the carload lot. The vendor-file reference must now indicate what parts each vendor can supply.

"Further sophistication is introduced by the requirements for immediate status reports. This requires "on-line systems" whose design requires more complicated file structures and advanced queueing-theory models to predict performance measures such as average waiting time.

"The above progression has required increasingly more complicated information processing techniques. It has also required the use of increasingly more complicated modeling techniques, both to implement the desired function and to design the information processing system itself. This simple example cannot adequately convey but can only suggest the enormous increase in complexity which may accompany an evolutionary development of the type described."

As the use of computer-based systems increases, more and more of the decisions formerly made manually by individual managers in functional areas become formalized and incorporated into computer programs, as illustrated for the inventory control application in the example given above.

The implications of this progression for educational programs are:

a) An increasing proportion of "management" time will be used to develop rules which can be implemented by computers rather than managers computing specific values themselves.

b) Formalized rules require use of quantitative modeling. The manager will need to become more of an engineer and less of an architect.

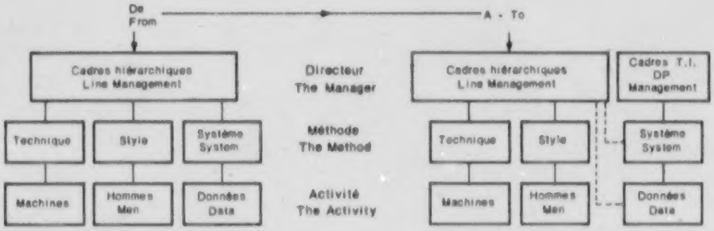
c) Change will continue over the foreseeable future and, consequently, each manager will continue to need training to acquaint him with new material. Consequently, the content of courses for each level of training will change over time.

ROLE OF SYSTEMS DEPARTMENTS

The importance of computer use has changed rapidly over the past two decades, and there is every indication that it will continue. The primary driving force is the technological development that changes the data processing capabilities of the hardware and, what is even more important, changes the relative economics of different processing methods. The rapid increase in performance and development of new capabilities is also well known, and it is generally accepted that such developments will continue. (See, for example, Withington, 1972.)

The growth in the scope and complexity of computer-based systems has led to several changes in the way organizations deal with information systems. (An excellent survey of this evolution is given by Benjamin, 1972.) One result of increasing use of computers in organizations has been the establishment of "Systems Departments" with responsibility for the design, development, operation and maintenance of computer-based information systems. To some, these departments may seem evolutions of the Systems and Procedures or Office and Methods Departments, but these new departments have so much more stature and importance that they can be considered a new development. The manager is frequently equal in stature to managers of the traditional over functional areas - production, marketing.

The advent of the Systems Department has made a fundamental change in the way in which management controls its activities. One way to show this is in the following diagram, adapted from Manley (1972).


De
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Cadres hiérarchiques
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Machines
Hommes
Men
Données
Data
Activité
The Activity
Machines
Hommes
Men
Données
Data

These Systems Departments have an impact on training requirements because they are of sufficient size to require management personnel of their own.(1) Furthermore, a substantial amount of the work is in system development which requires project management skills rather than the traditional functional area skills.

There are also training requirements for the analysts and programmers employed in these departments. In the past, analysts and programmers have frequently not been considered management. However, this question has recently been examined by the United States Department of Labor in relation to whether computer personnel are exempt from the provisions of the Fair Labor Standards Act. Exemption is granted to "... any employee employed in a bona fide, executive,

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1) For a discussion of the Organization of Systems Departments see Withington, op.cit., 1972.

administrative, or professional capacity ..." Perhaps the most relevant conclusion is the following (Federal Register, p.22978):

> "In the data processing field some firms employ persons described as systems analysts and computer programmers. If such employees are concerned with the planning, scheduling, and co-ordination of activities which are required to develop systems for processing data to obtain solutions to complex business, scientific, or engineering problems of his employer or his employer's customers, he is clearly doing work directly related to management policies or general business operations."

The growing need for management in the new "functional" area was also recognized:

> "In the data processing field an employee who directs the day-to-day activities of a single group of programmers and who performs the more complex or responsible jobs in programming will be considered to have management as his primary duty."

Organizations differ in the responsibilities assigned to the Systems Department and those assigned to user departments. One area of difference is the determination of requirements or specifications for proposed systems. In some organizations this is the responsibility of the user departments, in others it is initiated and carried out by the Systems Department. Consequently, in many organizations there is considerable mobility among analysts and management trainees in user departments. This can be expected to continue and indicates that educational programs should provide the necessary flexibility.

TRAINING PROGRAMS REQUIRED

On the basis of the above analysis, the training programs required include programs for line and staff managers in the functional areas and in general management, for managers in the new functional area represented by the Systems Department and for analysts and programmers engaged in this area. Analysts and others concerned with the design, construction, installation, and operation of systems for organizational purposes are included because they are doing work that would formerly have been the duty of management and because there will be considerable mobility between management positions in the functional areas and positions in the systems department. Many individuals starting out as analysts may become line managers and, similarly, many individuals who have some time in the line management positions may become managers in the systems department.

One basic question is the point at which educational programs can start; in particular, is university education necessary? The opinion of the U.S. Department of Labor regarding university education requirements (Federal Register, 22979) are:

> "The question arises whether computer programmers and systems analysts in the data processing field are included in the learned professions. At the present time there is too great a variation in standards and academic requirements to conclude that employees employed in such occupations are a part of a true profession recognized as such by the academic community with universally accepted standards for employment in the field."

The learned professions are defined:

> "Generally speaking the professions which meet the requirement for a prolonged course of specialized intellectual instruction and study include law, medicine, nursing, accountancy, actuarial computation, engineering, architecture, teaching, various types of physical, chemical and biological sciences, including pharmacy and registered or certified medical technology, and so forth. The typical symbol of the professional training and the best prima facie evidence of its possession is, of course, the appropriate academic degree, and in these professions an advanced academic degree is a standard (if not universal) prerequisite."

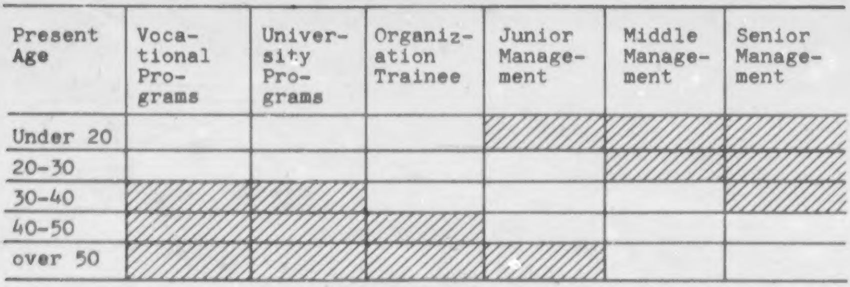
A university degree may not have been necessary for a position in information systems in the past, but informal surveys show that a college degree is an implicit if not explicit requirement for information systems positions in medium to large size companies using third generation equipment.

The following assumptions are made in developing the recommendations for training policies and programs:

1. The technology of computers and computer equipment is still changing at a rapid rate, and therefore the alternatives that are available, both on the hardware side and on the organizational side, are changing sufficiently rapidly that the content of courses is likely to be changing.
2. Education and training in computer-related topics for management will continue throughout the individual's career and formal training will supplement the on-the-job training.

This leads to a set of recommendations in which different educational programs and material are required for different job classification and different age brackets. Figure 1 shows the combinations for which some formal education should be available. The recommendations in the following Sections describe the contents of these components at the present time. As individuals advance through the age bracket and job classification, the content of the components will change in the future.

Figure 1



Present Age	Vocational Programs	University Programs	Organization Trainee	Junior Management	Middle Management	Senior Management
Under 20				▨	▨	▨
20-30					▨	▨
30-40	▨	▨				▨
40-50	▨	▨	▨			
over 50	▨	▨	▨	▨		

TRAINING AVAILABLE, TYPE AND QUANTITY

Management training in the United States is accomplished primarily in business schools through undergraduate and Masters of Business Administration programs. The type of computer-related material covered in these courses has been surveyed by McKenney and Tonge (1971). A useful source of material relating to such courses is given by Couger in the "Computing Newsletter for Schools of Business".

In-house training courses are offered by many organizations. There is however relatively little information on these programs available in the public literature and relatively little statistical data. There is somewhat more detailed information available regarding computer personnel, including analysts and programmers. The Bureau of Labor Statistics has forecast the requirements in various occupational classes. Some of the relevant data are summarized in Table 1.

According to the Bureau of Labor Statistics the number of new positions in Systems Analysis during the period 1968-1980 will be approximately 27,000 per year and another 23,000 will be needed in programming. This may be compared with 20,000 physicians, 33,000 accountants, and 73,000 engineers needed annually. An extensive review of sources of trained computer personnel has been conducted by Gilchrist and Weber (1972). Their estimate of sources of training is shown in the table on the next page. They also analyse the employment of trained personnel.

A fundamental difficulty in educational policy is adjusting supply of qualified personnel to meet demand. The recent experience in the United States points to the additional problems in a field where technology changes rapidly and where a considerable part of the training is in-house. A few years ago the shortage of qualified applicants for data processing positions was commonly accepted. The Bureau of Labor Statistics related its estimate of manpower requirements for the period 1968-1980 mentioned above. In the last few years

Table 1

GROWTH IN SELECTED OCCUPATIONS IN THE UNITED STATES 1968-1980

Occupational Group	1968 Employment	Percent Growth Forecast 1968-1980	Net Increase in Occupation	Average Annual Openings (not including Transfers)
All occupational groups	75,920,000	25.3	19,100,000	
All professional and technical	10,325,000	50.1	5,175,000	
Programmers	175,000	129	200,000	23,000
Engineers	1,100,000	40.2	400,000	73,400
Accountants	500,000	43.4	220,000	33,200
Systems Analysts	150,000	183	275,000	27,000
Physicians	295,000	53.1	155,000	20,000

Source: Bureau of Labor Statistics, 1971.

Table 2

SOURCES OF INFORMATION PROCESSING TRAINING
REPORTED BY RESPONDENTS TO THE 1971 AFIPS PERSONNEL SURVEY

Source	Percentage(1)
Computer Manufacturers	47.1
In-House	44.5
Part of Formal Education	37.5
University/College	31.4
Software Consulting Co.	8.5
EDP School	6.0
Correspondence School	4.5
High School/Vocational School	1.5
Other	9.2

1) Percentages add up to more than 100 due to multiple responses.

the shortage of personnel is much less in evidence, and some of the urgency seems to have gone out of the need for academic programs. Hamblen (1972), for example, concludes:

> "When the figures of supply are compared with estimates of demand we see that there is no longer a need to encourage a crash effort to start new degree programs at any level. However, if we examine the course offerings of the associate and bachelor's degree programs, in particular, as I have had occasion to do in the two NSF Inventories, there is definitely a need to strengthen these programs both in facilities available and course offerings."

The source for the estimate of demand used by Hamblen is the survey made by Gilchrist and Weber (1972). They summarize their study as follows:

> "Despite the collection and publication of much information by various private and governmental agencies, it is still impossible to make an accurate estimate of the number of computer personnel as defined in this paper (or by any other definition for that matter). Certainly, it is in excess of the 800,000 indicated in the following table.

ESTIMATE OF TOTAL PERSONNEL EMPLOYED BY FEDERAL, STATE AND LOCAL GOVERNMENTS AND NON-AGRICULTURAL ESTABLISHMENTS

Occupation	Employed(1)	Per 1000 Covered Employees	Ratio to Systems Analyst
Business Systems Analyst	97,000	1.4	1.0
Business Programmer	137,000	1.9	1.4
Computer Operator	173,000	2.5	1.8
Keypunch Operator	384,000	5.4	4.0
Total of Above	791,000	11.2	8.0

1) Includes scientific and engineering personnel employed by government.

> "The number of computer personnel most likely exceeds one million as shown in the following table:

FINAL ESTIMATE OF TOTAL U.S. EMPLOYMENT OF FOUR CATEGORIES OF COMPUTER PERSONNEL FOR 1970

Occupation	Employed
Systems Analyst	150,000
Programmer	210,000
Computer Operator	200,000
Keypunch Operator	440,000
Grand Total	1,000,000

> "Since criticisms can be levelled against both estimating procedures, the discrepancy is probably not surprising.
>
> "Our estimates are remarkably close to those made by the BLS in their Occupational Outlook Handbook. Their estimates are based on the average staffing per particular size of CPU, the numbers of the various size CPUs in use, and correction factors for productivity changes. This approach, which is entirely different from ours, yielded estimates of 150,000 systems analysts, 175,000 programmers and 175,000 computer operators for 1968.

"Due to the lack of use of standard occupational classifications, any attempt at disaggregation into occupational specialties may really be more a matter of speculation than enumeration.

"Since the major objective of collection and publication of these data is to provide information for manpower planning (i.e. the matching of the numbers of persons trained to those needed for a particular occupation), the lack of detailed estimates is a serious problem. The result so far has been a period of serious manpower shortages from about 1960 to 1969 followed by the present condition of moderate oversupply. Further, present and future prospects are for large oversupplies in some occupational specialties while at the same time there are critical shortages in others.

"It is clear that total employment of computer operators, programmers and systems analysts is not significantly greater than 560,000. In our companion paper we found that the current annual production of people trained for these jobs is over 170,000. To employ these would require a new entry rate of about 30 per cent which is much higher than the estimates of relative openings given by BLS of about 11 per cent for computer operations, 13 per cent for programmers, and 18 per cent for systems analysts. Thus, current production trends are not commensurate with current employment needs.

ESTIMATES OF NUMBER OF ENTRANTS INTO THE LABOR FORCE
FROM VARIOUS FORMAL COMPUTER EDUCATIONAL PROGRAMS
IN 1971

Educational Program	1971 Graduates	Entering Labor Force
High School	33,000	7,600
Public Vocational School	45,400	27,000
Private Vocational School	79,000	79,000
Associate	7,495	5,000
B.A./B.S.	3,350	2,300
M.A./M.S.	2,070	1,400
Ph.D.	335	110
Totals	170,650	122,410

"With the exception of the Private Vocational Schools each program is producing a steadily increasing number of graduates and entrants to the labor force. There is, unfortunately, insufficient data to break down the 1971 entrants to the labor force into job skills. However, one can roughly say that the first three categories in the above table will primarily enter date-entry, electrical accounting machine and computer operations while the last three categories will primarily enter programming and system analysis. The holders of Associate degrees will divide - the top students going into programming and the others into machine operations."

From the above analysis and that given by Gilchrist and Weber (1972) and Hamblen (1972) it is evident that the requirement for qualified analysts and programmers is far from being satisfied by graduates of available academic programs (as opposed to graduates of informal on-the-job training), and while it is perhaps not necessary to start many totally new graduate programs, we fully agree with Hamblen that many of the existing ones warrant improvement, particularly in course offerings. The analysis supports the conclusion that different education will be required for different classification. In particular, many more graduates with B.S. degrees will be needed than graduates with M.S. degrees because of the relatively smaller proportion of the most highly skilled analysts needed. In the past the sources of training for many individuals was "in-house" or the manufacturer. With increasing complexity of information technology and higher aspirations for systems expected by the user, such training will not be sufficient for at least a substantial portion of analysts, and consequently the most important educational programs (in terms of pace and time) will be those offered by the universities. These are discussed in the next section.

RECOMMENDATIONS FOR UNIVERSITY EDUCATION

While today a university degree is not an absolute requirement for entry into management positions, in the future the number of entrants without a degree will steadily decrease. Computer related educational programs should be divided into three major categories: programs for students interested in management positions in the functional areas; programs for students planning entry into systems departments (analysts, programmers, project managers, operations managers); and programs for computer specialists (systems programmers).

a) Programs for Students Interested in the Management Profession

Most of the students will enter Business Administration programs, though many enter management from liberal arts or engineering programs. To ensure that these students receive sufficient knowledge of the computer, these programs should contain one or two courses specifically dealing with the use of computers in organizations. In addition, courses in other subjects should include the use of computer-based systems in these areas.

b) Programs for Students Planning an Entry into Information Systems Positions

As stated earlier, the number of positions in information system development is increasing, and these should be regarded as management positions. The need for educational programs in this area has been studied by the ACM Curriculum Committee on Computer Education for Management and the results have been published in a position paper (Teichroew, 1971), recommendations for a graduate program (Ashenhurst, 1972), and recommendations for an undergraduate program (Couger, 1973). These recommendations are based on the recognition that information system development is in effect "organization engineering", and therefore the student should be equally knowledgeable about organizations and how they work as about computers and how they work. He should also develop some engineering skills: modelling and design. Students completing these programs would be prepared for entry level positions in Information Systems departments. Depending on their own interests and opportunities available they could pursue careers leading to management positions in other parts of the organization, management positions in the Information Systems Department, or as information systems professionals.

c) Programs for Computer Specialists

The number of positions available for computer specialists will be much fewer than those for the two categories mentioned above. A degree, preferably a graduate degree in Computer Science or Computer Engineering, will be a necessity. While most of the educational program will be devoted to technical subjects, it would be desirable to these students to have at least an introduction to the role of computer-based information systems in organizations.

TRAINEE PROGRAMS

Many organizations have management traineeship programs in which recent university graduates spend from a few months to perhaps a year-and-a-half in several positions. These programs can be extremely useful in providing future managers with a knowledge about the management considerations involved in computer-based systems, particularly if the university program has been in an area other than Business.

All management trainees should spend perhaps as much as one-third of their time in the Systems Department. During this time they should be introduced to the system development procedures used in the organization and become aware of the problems of managing large-scale development projects. They should also become aware of the difficulties of establishing user requirements and the importance of user participation in the eventual effectiveness of the system. Taking part in an audit of a system recently completed or one which is not effective is frequently an excellent method for realization of the complex interrelationship of many factors in effective system development. Similarly, trainees headed for entry positions in the Systems Department can be made aware of the user's side by participating in the development of specifications for a new proposed system.

JUNIOR MANAGEMENT PROGRAMS

After a new employee has completed his traineeship program and worked for a number of years, his career goals will become more specific and in line with the general assumption that formal education must continue throughout the career in parallel with on-the-job training, and some formal training is desirable. In most cases, organizations will not wish to develop their own courses but will instead use outside facilities.

For the exceptional individual a graduate program at an established university will be worthwhile. For others a part-time evening degree program should be encouraged. Such programs are desirable for their general education as well as the specific skills and knowledge they impact. For most of the employees in this category, however, formal education will consist of "short" courses and seminars on specific topics. For managers in the functional areas, the most important courses are those dealing with advanced applications in their own areas. These courses are offered by universities as two- or three-week courses; sometimes they are organized by the professional societies. See, for example, Armstrong (1972) and Hammond (1972).

For information system specialists who are being promoted to management positions in the Systems Department, the most important training is in management techniques, particularly project management techniques. Courses in these topics are offered by the Business Schools, professional associations and sometimes commercial training institutes.

MIDDLE AND SENIOR MANAGEMENT PROGRAMS

By the time an individual has reached the middle management level he has demonstrated ability to manage in a given area and to keep abreast of developments that affect that area. He is then aspiring to positions that involve more of the organization than one area. This is exactly where computer based systems are creating opportunities and stresses (perhaps unrecognized).

Since middle managers are busy and have many responsibilities, training programs must be designed first of all in small units - one-half day or perhaps a day. The basic emphasis must be on convincing the manager that a topic or subject is important enough to look into, rather than supplying detailed information on which a decision can be based. All too often middle management courses overemphasize the presentation of technical facts or lower-level skills (e.g. computer programming) in which the managers show interest but which does not change their behavior when they return to their daily environment.

The considerations outlined above for middle management apply even more sharply for training courses for senior executives. The emphasis in the design of such courses must be even more on the desired change in the behavior of the managers completing the course. A study of how effective they are has recently been completed by Ruth (1971). One source of information about programs for orienting the manager to the computer is given by Harold (1971).

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VI

PHILOSOPHY AND CONTENTS OF TRAINING FOR COMPUTING

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INTRODUCTION

The academic discipline of computing has become increasingly accepted and respectable at United States institutions of higher education during the past few years. There are more and more departments of computing science (known in various guises as data processing, information science, information processing, or my preference of computing and information systems which is hardly used) as well as computing options embodied within more established departments of mathematics or electrical engineering. Indeed, this rapid proliferation of educational programs has given rise to a number of concerns about these programs. Have we gone too far too fast? This paper addresses some of these concerns, based principally on my experiences with United States educational programs. My travels in other countries indicate that similar problems exist elsewhere, except that in most cases educational activities in computing lag those in the United States. The period of lag usually reflects the developing status of the country, or the inability to commit resources required in establishing an educational program in computing, or restrictions imposed by academic structures and attitudes. At Western European universities academic programs in computing date back about six years(1)*; Israeli computing academic programs are approximately four years old(2); South American countries about three years(3), (4); programs in African countries date back only one year or so.

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* Figures in brackets refer to the list of References at the end of this Chapter.

In the United States, history is almost equally brief, going back about twelve years. The rapid growth of university computing centers during the 1960 to 1965 period resulted in an increasing awareness of the need for associated educational programs. The first serious studies occurred at the Universities of Michigan and Houston (5), (6), (7). The heavy emphasis on mathematics and engineering in these programs continues to this day. With this start the proliferation of academic programs assumed epidemic and uncontrolled growth during the 1965 to 1970 period. Programs abounded at private vocation schools (certificates of dubious value), two-year colleges (Associate degree), four-year colleges (Bachelor degree) and at universities (Masters and Doctorate degrees). More recently there have even been proposals to have two-year colleges offer four-year programs in computing (8). Some of these growth patterns are reported by Keenan (9) and Hamblen (10) and (11).

This galloping growth stimulated attention by government agencies (12), (13). Studies by professional organizations and universities also provide general and specific information [(14) and (15) for the engineering and mathematics thinking, (16) and (17) for university conferences]. On a continuing basis, publications of The Association for Computing Machinery (ACM) especially the *Communications* (18) and the *Bulletin* of the ACM Special Interest Group on Computer Science Education (19) provide informative material (see especially the SIGCSE Technical Symposia Bulletin issues in 1970, 1972 and 1973).

The report of the ACM Curriculum Committee on Computer Science, Curriculum 68, has had the most profound effect (20). It gave the computing discipline a scholarly respectability, an intellectual base and a comprehensive content. Curriculum 68 created the mold and most United States universities attempted to fit that mold when establishing academic programs in computing. But many have found the Curriculum 68 mold too confining: the products of Curriculum 68 type programs are more theoretician than practitioner, more mathematician than engineer.

In the remainder of this paper I offer some impressions on educational programs in general and computing education in particular. Many of these comments contrast with the Curriculum 68 approach.

SUPPLIERS OF COMPUTING EDUCATION

People enter the computing field through many ports: some from other fields such as engineering and mathematics, some with minimal educational backgrounds (high school) after taking courses offered by manufacturers or private vocational schools, and an increasing number from the academic computing programs at institutions of higher education. Seegmüller (21) refers to this phenomenon as the migration or diffusion of employees of completely different and unrelated professions - "bakers, truck drivers, butchers, secretaries, salesgirls, etc." - into the computing environment. Gilchrist (22) indicates (from admittedly sketchy data) that the largest percentage of computing practitioners in the United States are products of manufacturer courses and vocational schools (excluding those who graduate from university programs in other disciplines).

If we accept the fact that computing is truly an academic discipline then we must accept the consequence that the professional practitioner requires a four-year college education. Most people have by now accepted the "intellectual respectability" of computing and the benefits of college exposure. For example, the National Academy of Science report (12) notes that over 50% of those entering the computing field for the foreseeable future (as of 1966) will require college degrees. An American Federation of Information Processing Societies survey (23) found that almost 70% of the respondents possessed a college degree.

With this premise we must view as suspect the graduates of private vocational schools or manufacturer-sponsored courses who "without ever having had a sound education" (21) enter the computing field as operators and in time progress to programmers, analysts and consultants. Seegmüller (21) refers to these people as "underground experts" and states that manufacturer-offered education "has to be viewed just as a disgrace to culture". Mercouroff (24) notes the exploitation of the appeal to be a computer expert by certain private enterprises, "some specializing in the sale of computer courses, while others dealt in pipe dreams".

There are technicians in the computing field (progressing from keypunch to computer operators) who require a high school, vocational or two-year college education. However, we must not confuse these with computing professionals who require a "sound education". In the following sections we attempt to define the "soundness" of technology oriented education in general and computing education in particular.

Before doing so we should consider the implications of unsound education, whether at the technician or professional level. In computing education we have adopted few control mechanisms to assure quality either in the vocational schools or in their graduates. We allow all to enter the computing field with little safeguard against substandard quality. The situation of two-year colleges is not quite analogous since there usually exist some quality control mechanisms at these institutions; yet we assume that graduates of these programs are eligible for professional positions. Increasingly we hear calls for certification of institutions and licensing of their graduates.

(Recently the ACM and the DPMA initiated efforts which may lead to personnel certification.) Computing has become one of the biggest industries in the United States with over two per cent of the Gross National Product expended on computing hardware, software and associated services (25). Yesterday's informal methods no longer suffice in today's society. We must undertake whatever steps are necessary to assure that our practitioners are qualified and competent.

PHILOSOPHY OF TECHNOLOGY ORIENTED EDUCATION

Until recently it was accepted that the technology oriented student received an undergraduate education concentrated in his particular field. Thus the engineering student was exposed to an almost endless program of engineering and related science (mathematics, physics, chemistry) courses, constituting perhaps 80 to 90% of his courses. At the present time this is still the general practice in the United States. It is true even more so in other countries with the faculty chair and specialized institute structures where students normally take all the courses in their faculty.

In the past few years this practice has been questioned and, at least in some instances, found wanting. The most visible example of such self-examination has been at the Massachusetts Institute of Technology, the epitome of technological education in the United States. Several years ago MIT established a Commission on Undergraduate Education to study the academic program. Preliminary conclusions (26) identified three basic aspects of undergraduate education:

a) Integration of Knowledge: This concept usually means interdisciplinary curricula or general education. More specifically, the modern problems of civilization will require that students develop the ability to synthesize as well as to analyze.

b) Relation of Facts and Values: We define and produce engineers and scientists without including intellectual tools from the humanities in their required mental kit. This is particularly significant today because the most difficult problems we face are those which relate facts and values.

c) Education for Citizenship in a Democracy: To some people these days this sounds a bit "square". But it has never been more important for students to understand the nature of a democracy and their roles as individuals in it.

Some time later the parent Commission on MIT Education issued an initial formal report, Creative Renewal in a Time of Crisis (27). The recommendations in this report broaden and modify the above concepts:

a) General Objectives: We begin from the premise that MIT should maintain its historic commitment to excellence in the main fields of science and technology. This commitment, however, must be joined to a recognition of the pressing need to unite the pursuit of knowledge with a concern for social responsibility in the use of that knowledge. MIT graduates must be prepared not only with the skills they will need to excel as scientists, engineers and administrators, but also with the breadth of understanding they must have if they are also to become responsible professionals.

b) Undergraduate Education: Throughout American higher education, the undergraduate years have increasingly come to be devoted to preparation for graduate training. At MIT, where professional education has always been a central concern of the undergraduate program, we have been moving in the opposite direction to provide a broader foundation for professional education. This movement should be intensified by establishing a new First Division, the responsibility of the institute faculty as a whole, as an institutional focus for general education during the first two years. The overall aim would be to encourage students to develop a broader outlook as well as individual capacity for creative synthesis and self-education.

c) Graduate Education: Graduate education should be re-examined to cultivate a deeper understanding of the social consequences of science and technology, to improve opportunities for graduate students to acquire training in teaching, to develop broader (three year) interdisciplinary programs leading to the Master's degree, and to develop pre-doctoral intermediate degrees that do not require an original contribution to knowledge but recognize a dimension of excellence in another area.

d) Knowledge and Values: MIT should take seriously the intellectual problem of defining the relation of knowledge to values, of improving performance as an environment for humane learning and of stressing a commitment to public service. The separation of scientific activity from broader cultural pursuits and intellectual concerns has all but destroyed the capacity of academics to think of themselves as members of one common profession; problems that arise at the interface of the disciplines tend to be neglected or are too difficult to approach. The current atmosphere does not adequately encourage humane learning; too many faculty members and students continue to think of the humanities as unimportant, irrelevant and methodologically soft. Immense value is

> placed on technical problem solving, on productivity, efficiency, action, organization - to the detriment of more contemplative, casual and spontaneous modes of intellectual life. Without losing the great virtues inherent in these values, we must do more to make room and time for reflectiveness. If we expect to have any impact on the social and cultural problems which result from the fragmentation of knowledge, we ought to begin grappling with those problems here first.

Clearly many of these recommendations conflict with the conventional wisdom. It may not be feasible to implement all recommendations at all institutions in all countries. In fact, it may not be desirable to do so; developing countries for example have certain unique priorities and problems. Yet I believe that the philosophy expressed in these recommendations should receive serious consideration and be implemented to the degree possible. I am concerned that too often in our haste for quantity we forsake quality, we forget that the purpose of education is to educate the whole man. This philosophy affects my concepts of computing education, expressed in the following section.

PHILOSOPHY OF COMPUTING EDUCATION

As already noted, Curriculum 68 has had the most profound effect on computing education; many institutions view it as the yardstick by which to measure the adequacy of their programs. And in the main this has been beneficial, by setting certain standards and defining content. On the other hand, Curriculum 68 is in the tradition of professionally oriented programs. It recommends that ten computing courses and six mathematics courses be required, with an additional three computing courses and an unspecified number of mathematics courses as electives. The products of such a curriculum are certainly well versed in computing and mathematics, but are they really the products we should produce? The MIT reference above would, on the basis of the philosophy expressed, indicate not; moreover an increasingly larger number of computing professionals are questioning this approach.

Oettinger (16) first notes "...that if we keep advertising ourselves as computer scientists, we are dangerously misleading ourselves, our students and the world at large. At the very least the title should be Computer Scientist and Engineer." Further, he notes: "In our rush to be accepted as scientists and engineers and to mold students in our image, I hope we are not going to make the mistake of prescribing narrow curricula restricted entirely to technical subjects....we cannot afford to produce students who are ignorant of fundamentals, whether of physics, mathematics or fundamental branches of engineering. Our students should be well versed in economics, well versed in the social sciences." He is appalled by the spectre of the army of technicians that we might otherwise create.

Mercouroff (24) notes that computer specialist training is bound to become steadily broader. Rapid technological change increasingly calls for general education. Further, the many new uses of information processing require training in some additional field. Accordingly, the number of pure computer specialists will decrease.

Seegmüller (21) sees his ideal graduates as those who possess knowledge of one or more problem areas besides computing: who see implications, interdependencies, constraints, far reaching consequences in human organizations; are very good in communicating and cooperating with many other people; are resourceful with a well-balanced attitude towards efficiency. "This is the 'superman' many organizations are watching out for so that he can solve their organizational mess (which was brought into the open when they set out for 'automation')." Indeed, this parenthetical remark is most valid. Many organizations have tried to "automate" simply by acquiring a computer. It is a fact of life that automation brings with it fundamental changes in systems approach, organizational structure and human relationships. Ignorance (too often by the "computing experts") of these implications dooms the implementation to failure.

In an article with Ralston (28), I proposed a more liberal undergraduate education than Curriculum 68 for the following principal reasons:

a) Computing pervades many disciplines: the computing student should have a background in the disciplines to which computing contributes as well as those which contribute to computing.

b) The communications gap between the user of computing technology and the computing practitioner may be remedied by exposing the computing student to user disciplines, rather than relying on the user to absorb the new technology.

c) Engineers and scientists are being held increasingly accountable for the effects of their work on society. If computing technology is to contribute to the meaningful development of society, the computing scientist must be a well-educated and informed citizen.

Finally, and on pragmatic grounds, I note that Curriculum 68 implementation requires a fair amount of resources - in staff, space, equipment and funds. These resources simply may not be available. An ACM Subcommittee on Small College Programs has attempted to shape Curriculum 68 recommendations within the small (liberal) college environment (29).

THE EDUCATIONAL PROGRAM

The points of view expressed above suggest that computing educational programs should be interdisciplinary with breadth in a variety of subjects and depth in more than the computing subject. This is especially true at the undergraduate level, and to the degree possible it should follow through at the graduate level. Such an undergraduate program should make it possible, indeed encourage the students to obtain a "double major" degree, i.e. in computing and some other discipline. It might have the following constituents, based on the normal undergraduate programs in the United States consisting of approximately forty-one semester courses:

a) Required Core: The core would consist of fourteen to fifteen courses - five required in mathematics, five required in computing, two in engineering and two or three electives from these areas.

b) Required distribution: Fourteen to fifteen courses would be distributed over other fields - five from the sciences and engineering, and nine or ten from the humanities and social sciences.

c) Additional Depth: The remaining ten to twelve courses would be at the discretion of the student. He would be encouraged to apply them to one and no more than two disciplines so that he might fulfil the requirements of a double major. Note that students might well select courses from the humanities and social sciences to gain depth in these areas rather than the sciences and engineering.

Such a program infers the following points. First, the normal mathematics courses would be restructured. It has been remarked that perhaps ninety per cent of mathematics is not needed (by the computing student) in its present form. This may exaggerate, yet clearly there should be greater emphasis on discrete and applied mathematics.

Second, the computing courses should deal with the "engineering" aspects of hardware and software (and their integration) as well as the theoretical. Too often computing science programs tend to regard these aspects as "impure" (perhaps as pure mathematics tends to regard applied mathematics). We must keep in mind that computing spans a wide spectrum from abstraction to concrete application, from the purest of pure mathematics to the dirtiest of engineering. We should not be afraid to display our dirty fingernails. If indeed they are as dirty as they should be, let's be proud of it.

Third, we should not shy away from embracing business data processing aspects into the computing program. Too often we relegate this education to "someone else", because we regard business data processing as even more impure than engineering. We thereby encourage the vocational school (and two-year college) to take on this task. Those working in the business data processing field far outnumber those engaged in scientific computing. Our educational programs should furnish these students with an intellectual content similar to that furnished to the computer "scientist". Along these lines we should design courses on management of computing facilities, on software management, and on human and organization behavior among others. The ACM Curriculum Committee on Computer Education for Management has made a start in this direction with recommendations for a program in information systems (30).

Fourth, we must carefully examine the interface between computing and other disciplines. It is true that engineers (and computing students) regard the humanities and social sciences as irrelevant. Yet this attitude often derives from the fact that these courses are taught in so dry or uninspired a form as to be incomprehensible to the engineer.

Obviously, these things are not easily done. Some lie at the heart of the MIT report and require communication between faculties heretofore not achieved. In addition, they will make more possible the education of users in computing. The program outlined above is quite adaptable to such education by some shift in emphasis, with somewhat less in the computing core and somewhat more in the user core. However, these changes require a coordinated effort rather than the fragmented effort all too often taken for the sake of expedience.

FINAL NOTE

There is an explicit distinction between the computer as a tool and computation as a concept. The computer has given entirely new scope to the idea of computation - so much so that men who work with computers have found new ways of thinking, even in areas to which the computer as a tool may never be applied. The computer as a tool simply contributes to the prevailing technological gap separating individuals and nations. However, the widening communication gulf between people who employ fundamentally different strategies of thought, exploration and understanding is basically caused by the rise of computation. Too often our educational programs have emphasized the computer as a tool. Too often they have neglected to stress that the use of the computer stimulates and modifies intellectual processes. Those who are concerned with education must do justice to both aspects in the programs they establish.

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VII

COMPUTER SCIENCE IN SECONDARY EDUCATION

by

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INTRODUCTION

Until a few years ago computer science was mainly introduced into education in the form of "computer-assisted instruction". In other words, computers have so far been little used in education except to replace the teacher, with varying degrees of success.

In programmed teaching, "drill and practice" techniques or "dialogues", computers merely replace the teacher in transmitting knowledge and testing what has been learnt, with all the flexibility these machines are capable of if properly programmed.

However, a new tendency is emerging, based on the conviction that computer science is becoming an independent field and that its methodology can offer education much more than the automation of such largely minor tasks as the transmission of knowledge.

EDUCATION AND THE TRANSMISSION OF KNOWLEDGE

Education has long been considered as a system for transmitting knowledge and is still so regarded to a considerable extent. This is clear from the division of education into quasi-independent "disciplines" along lines which have little varied since Auguste Comte's day. The objective is to fill pupils' minds with as much information as possible, while the representatives of the various disciplines consider that the number of weekly teaching hours at their disposal is far too small to attain a certain level below which they cannot usefully operate.

In view of the steady increase in our knowledge it was natural to try to solve the problem of cramming a constantly expanding content, namely the knowledge to be conveyed, into a largely unchanged container, meaning the number of hours a pupil is expected to devote to his school activities.

On the strength of his outstanding work in animal psychology and the spectacular results he has achieved, Prof. Skinner has proposed that this problem should be solved by programmed instruction. Starting with the premise that education is a system for the transmission of knowledge, he suggests that the use of the pupils' "learning capacity" should be optimised by:

a) breaking down the recorded material into elementary facts and concepts which are carefully analysed and arranged in order of importance;
b) introducing pupils to these facts and concepts one by one in logical order;
c) ensuring that correct replies to the questions inserted between the items of information are rewarded by words of praise.

Even if this method is supplemented by improvements devised by Crowder and others in order to make the system more flexible, it singularly recalls the conventional techniques used to induce conditioned reflexes in living organisms.

There is nothing very surprising in the enthusiasm which this method aroused when it was first proposed, in view of the fact that much of our social life is based precisely on the assumption that man's capacity to be conditioned is infinite. Obvious examples are the kind of psychological suggestion and brainwashing practiced by the mass media, not to speak of the advertising techniques based on motivation studies. These psychological and sociological considerations alone would be enough to condemn this approach as a general method of education. We shall refer later to its use in certain specific cases, but there are even more disquieting developments.

It is obvious that such conditioning runs counter to the sort of adaptability which is more necessary than ever at a period when many specialists foresee that today's school children will have to change occupations two or three times in their working existence. It is obvious not only for such reasons of principle but also in practice, since any technique used to teach more things in less time has a twofold limitation: the speed it takes a human being to learn and the time he can devote to the learning process. As each of these terms is finite, the product of both is also finite, and this means that whatever the method used to transmit knowledge, there is an upper limit to the quantity of knowledge an individual can acquire in the course of his school life. But according to certain experts the quantity of information generated by our society now doubles every ten years, and there seems to be no foreseeable end to the process.

The result is that whether optimised or not any system of teaching based on the transmission of knowledge is bound to fail, since the effect of optimising a method is merely to postpone the hour of failure.

COMPUTER SCIENCE AND PEDAGOGICS

The dictionary defines pedagogics as the "science of education and instruction: the technique of teaching".

In view of the technological trend of the present age it is hardly surprising that most researchers should have concentrated on the second part of the definition, i.e. the technique of teaching. I can only wonder that someone has not imitated the American company which has adopted the name of Edutronics and has not suggested that the still new activity known as educational technology should be given the name of "instructics", "educatics" or even "teachics".

This outlook is very unfortunate in that not only can the "wood not be seen for the trees", but that (an infinitely more serious matter) it induces such an obsession with the means of teaching that the means have eventually become the ends. I shall mention but one example, which has the merit of being recent and is in my view absolutely typical.

In a publication on computer-assisted instruction which has just been issued the author does not hesitate to lay down the axiom that "teaching basically consists in transmitting information" to which the corollary is that the teacher, because he cannot be universal, forms a screen between information and the pupil. The conclusion is that it is far better to let the pupil obtain direct access to information rather than through such an imperfect, approximate channel as the teacher.

It would hardly be a simplification to say that all programmed teaching is based on this premise.

Admittedly, the latter justifies research of the type undertaken by an American team which, after several months' investigation, was amazed to discover that pupils faced with a list of random words memorised them much more easily when they were inserted into a meaningful text than singly. I am sure that everyone was duly edified when this truly surprising result was recently published.

This example among many others shows the degree to which American research is conditioned by behaviourism. This behaviourist approach is almost always implicit. Under the pretence of objectivity the pupil is treated like a black box, no explanatory model of the content of the black box is ever built and the consequences have been, and unfortunately continue to be, nothing short of disastrous.

Since the behaviourist approach ultimately threatens to negate the very idea of teaching, the working group of which I am chairman decided to start from a radically different basis. As computer science deals with the processing of information in the most general sense, and as education is substantially a way of processing certain information, we have attempted to apply the methods of computer science to pedagogics.

a) Attempt to apply the methods of computer science to pedagogics

As pedagogics is the science of education and instruction we felt that if we were to make any progress we needed a model of the individual for whom such education was intended, i.e. a model of the pupil himself. We were not looking for any universal model which would explain the details of a pupil's behaviour in all circumstances, since it would have been far too complex for use. What we needed was a model which was general enough to be really useful and yet precise and simple enough to be readily utilised.

Considering that pupils are, on the whole, intelligent individuals, the model we adopted for a pupil was purely and simply the computer-science definition of an "intelligent system". The definition is not new, as it is the basis for considerable research on artificial intelligence. In no case does it claim to describe the whole field of human intelligence. But however incomplete it is we shall see that it still has the enormous advantage of leading to a number of interesting conclusions. This definition is as follows:

"A system interacting with its environment is intelligent if:
- the system possesses a model of its environment;
- before action is taken to achieve some specific environmental effect the system tests its action by simulating it on the model;
- when simulation does not yield a favourable result other action designed to achieve the same effect is simulated until a course of action is discovered which is likely to be favourable.

"Action then taken to influence the environment may have two possible issues:
- if the environmental effect achieved confirms the simulated effect, the model is reinforced;
- if the environmental effect differs from the simulated effect the model is corrected in the light of the result obtained."

A possible objection to this definition is that apart from a few details it merely reproduces the definition that "a system is intelligent if it is self-adapting". However, the latter definition is of the behaviourist type; it is descriptive and ultimately unusable, whereas the definition we propose is of the computer-science type, enabling a utilisable model to be obtained.

It is moreover interesting to compare our definition of an intelligent system with the role which Prof. Jacques Monod assigns to the brain:

"- It ensures the control and the central co-ordination of neuromotor activity, as determined by afferent sensory impulses;
- In the form of genetically determined circuits, it contains programmes of action of varying degrees of complexity, which are triggered by means of specific stimuli;
- It analyses, filters and integrates afferent sensory impulses in such a way as to build up an image of the outside world which is adjusted to the specific performances of the particular animal;
- Depending on the range of these specific performances it records significant events and classifies them analogically. It associates these classifications according to the concurrent or sequential relationship of events making up the classifications. It enriches, refines and diversifies the innate programmes by including these experiences;
- It imagines, meaning that it represents and simulates outside events or programmes of action which are those of the animal itself."

We have quoted Prof. Monod at such length not so much to emphasize how closely related these two definitions are but to expand on certain points in our own definition.

b) The concept behind the model

The term model normally conjures up the idea of a mathematical model as commonly used by physicists. We are not using the term model in this sense. Indeed, as Prof. Monod points out, a model may be causal, analogical, quantitative, temporal, logical, mathematical, etc. and it may even be all these things at once, depending on which part of the model is considered.

Very generally speaking the model might be said to be a "fuzzy" relational system (in the sense in which Prof. Zadeh speaks of "fuzzy sets") which is formed by a network of connections of varying degrees of looseness according to the part of the network considered, does not necessarily form a whole which is entirely coherent (in the logical sense), but structures a set of memorised knowledge.

Naturally, the model must not be considered as a juxtaposition of memorised knowledge with a relational structure but as an interaction between the two. This means that the way new knowledge is acquired depends on the pre-existent model, which the acquisition of any new knowledge more or less radically alters (this primarily means that there is no pure phenomenon of memorisation except of course in certain processes of experimental psychology).

With reference to the remarkable research done by Prof. Piaget and his team on causal explanations, the model which the intelligent system constructs might be described as a dialectic synthesis of the operational attitude and the logico-mathematical attitude, these two terms being used as Piaget defines them.

It is important to emphasize, and we shall have occasion to revert to this point, that the model is used by the system as a forecasting model. As a result, the more extensive the environment to which the model relates the greater the capacity of the system for effective environmental action. However, as Prof. Monod points out, while the model-building process is innate it may be intensified, refined and developed.

In conclusion, it is clear from the two definitions that experimentation is the only guarantee of validity and the only way in which the model can be corrected, amplified and developed.

It was on the basis of these considerations that we believed the objectives of education could be defined.

c) Objectives of education

For many generations secondary education proposed to "train the mind" by means of Greek history and Latin versification. Knowledge and control of the environment was something which children were supposed to learn from their parents.

The introduction in France of compulsory, non-denominational, cost-free education did little to change matters as it was more or less confined to the four operations on real and rational numbers, to spelling and the list of the main towns in each French department - a hardly coherent body of knowledge which pupils had to learn by heart.

This whole system was challenged by the ever-increasing speed of technological growth.

Faced with the increase in the mass of accumulated knowledge, the educational system reacted by inflating the curricula and increasing the number of subjects taught. As the pace of technological progress quickened it had to call upon technology to try to teach more things in less time. Finally, disheartened by the increasingly rapid obsolescence of the knowledge acquired, educationists launched the slogan "teaching means teaching people how to learn", as if this formula which is nothing but an admission of impotence had any chance at all of solving the problem.

In view of what is now called the information explosion it is clear that conventional education, conceived as a system of transmitting accumulated knowledge, is on the brink of bankruptcy.

If we now reject the idea that education is the transmission of knowledge and analyse the approach to teaching by taking as our basis the model of the pupil considered as an intelligent system, the problem will then be seen in somewhat different terms.

We have seen that an intelligent system possesses a model of its environment and that this model is used by the system as a forecasting model developed and improved by experience. From this standpoint it may be said that "learning means learning to plan ahead", but although learning by experience is effective it is also the longest method.

In these circumstances, the major objective of education may be said to consist in reducing learning time by teaching, instead of knowledge, the models which make such knowledge coherent and therefore operational. From this point of view the slogan "teaching means teaching to plan ahead" means that each pupil is helped to build, within his own brain pattern and by using his own model, a coherent model of his immediate or remote environment so that he can exercise his activity, whatever it is, with a chance of increasing success.

May I point out that the model in question is not a mathematical one. While the latter certainly has proved its worth, it is by definition incapable of representing the whole complexity of the environment.

The term model here follows the earlier stated definition, and as such can be used in all disciplines, including those scarcely lending themselves to experimentation.

As previously defined the exact sciences provide models of the physical environment (physics, chemistry, astronomy, etc.), the human sciences models of the social environment (economics, sociology, etc.), while the arts and literature supply models of the human environment (aesthetics, imagination, emotions, psychological reactions, etc.).

COMPUTER SCIENCE AND EDUCATION

The purpose of the foregoing remarks has been to show that when applied to pedagogics computer science is an independent science whose function is to provide information for as well as to distinguish between the semantics and syntax involved. A logical resulting approach in computer science is therefore model-building.

An attempt was also made to show that this is a fundamental human mental process and that it can be improved by the right training.

This led to the conclusion that the transmission of knowledge should be systematically designed so that pupils can broaden, deepen and improve their model-building aptitudes rather than more or less completely reproduce some sub-set of knowledge which they have tried to memorise as best they can.

Teaching by models is usually pluridisciplinary by definition, since the mechanisms which control the environment cannot be forced into a mould like Auguste Comte's classification of the sciences.

It is admittedly difficult to introduce such a form of education, not however because its principles are so very new. Many teaching manuals show a trend in this direction. The real trouble consists in proceeding from the general discussion of some given problem to the stage where the model is systematically used for teaching purposes.

Teaching by models raises two further problems which are incidentally connected. The first problem arises in analysing the actual teaching process from an information-processing standpoint. A teacher who wishes to transmit an idea or a concept can only use the spoken or written word (let us disregard drawings, photographs or films, which would only complicate the problem). The set of words he utters he has selected because he feels they are most likely to reflect his thinking precisely. The pupil registers a pattern of sounds which he analyses and tries to reconstruct the meaning of the sentence with the help of the usual linguistic conventions. Reconstruction is the work of the pupil and nobody else.

We do not propose to revert to Piaget's well-known experiments which show that certain concepts cannot be communicated until the pupil has reached a certain mental age. But it is pretty clear that the meaning as reconstructed by the pupil will invariably depart to some extent from the meaning the teacher wishes to communicate, and that the gap will obviously not be the same for each pupil. The situation can be summed up in the well-known saying about the teacher simultaneously giving as many lessons as he has pupils. This problem of communication is particularly acute when models are used, i.e. with teaching relationships between things rather than the things themselves.

The second problem, which is more or less connected with the previous one, consists in testing the model by comparing it with real life situations.

We have already seen in connection with the definition of the "intelligent system" that the model constructed by the system can only be reinforced or corrected through experimentation. Only by testing actual situations will the pupil be able to correct any deviation between the model the teacher has tried to communicate and that which the pupil has actually built himself.

Testing is therefore an absolute requisite, but, quite apart from the cost, how can the time and above all the facilities be found for testing a model of urban growth or an ecological model?

Computer-assisted instruction

Although experimentation at the actual scale is always desirable it is unfortunately almost never possible. For teaching purposes, however, a computer-simulated model can be an effective substitute. In our view this is one of the major educational roles which the computer will be expected to play.

Since teaching has been regarded as the transmission of knowledge, the natural reaction has been to use the computer for the same purpose by having it take over some of the work from the teacher.

In the extreme case there would be no reason why the whole task of teaching should not be transferred to the computer, which would simultaneously play the part of a gigantic data bank, a source of documentation and a reservoir of standard lessons in every conceivable field.

Such ideas have been put forward very seriously together with considerations on the changing role of teachers, who would thus be relieved of routine duties as educational psychologists and could statistically analyse pupil achievements plotted in more or less complex diagrams covering each subject.

This is not to say that in certain cases the computer is incapable of playing such a part. The odd, yet hardly unexpected outcome is that several educationists should have promptly regarded partial tests as general proof and elevated this method of using the computer into approved dogma. Such an attitude should not really cause surprise since it is a logical development of the computer's history. For it must be admitted that the use of computers was initially proposed by computer specialists. Not being teachers they stopped at the most superficial aspect of the teacher's task, i.e. the transmission of knowledge, and eagerly staged experiments to prove their point. The teachers attracted by these experiments for their part did not know how computers worked or what they could do, and so continued to think along the lines suggested by the computer specialists.

It is only recently that a number of teachers have gained a fuller knowledge of computer capacity and computer methods, and have accordingly approached the basic issues afresh.

There is a striking similarity between experience with computers in education and in management.

In management a start was also made by using the computer for minor tasks (pay-sheets, invoices, etc.) until managers came to realise what the instrument could do. Only then did the real computer revolution in industry begin: manual techniques were jettisoned and the radical overhaul of management methods which we are now experiencing was undertaken.

The process is now a standard one, and it would indeed seem that the present growing pains of computer-assisted instruction conform to the pattern. Up to now computer-assisted instruction has been in the hands of computer experts and subject therefore to every sort of trial and error from a teaching standpoint.

Only recently have teachers begun to tackle the problem and, despite blunders due to unfamiliarity with computer science, it would seem that a good start has now been made. Any problems arising from the use of computers in education have much more to do with teaching than with the computer and can only be properly tackled by teachers themselves.

COMPUTERS IN EDUCATION

It emerges from the foregoing that the computer is simply a tool and that what really counts is the methodology of its use.

In many places it is considered that the problem of teaching computer-science is met when a number of lessons have been given on computer structure, technology and language. But it would seem that the real problem has been bypassed.

From a technical and technological standpoint, in secondary education the computer is neither more nor less important than such other products of our era as the turbo-reactor, the internal combustion engine, the telephone or television. While a few lessons devoted to the computer are always worthwhile, this is far removed from teaching computer science.

From the standpoint of programming languages, it is increasingly obvious that these are part and parcel of the computer tool and come under the heading of technique. It is, of course, essential that pupils should learn a programming language if they have access to a computer, but it would be dangerous to consider that they have been taught computer science simply because they have learnt the language.

The fact is that learning a computer language does not help anyone to use a computer for solving a problem any more than learning to drive makes it easier to pick out the best route on a map. An even more serious problem is that a programmer who knows only one language may eventually be able to deal with a number of problems on a computer but does not know what he is really doing. The best proof of this is the programmer's endless difficulty in trying to learn another type of language (e.g. COBOL for a FORTRAN computer).

This is because a programmer sees his computer language as a set of more or less arbitrary constraints through which he eventually discovers methods for expressing the problem he wishes to solve. If he alters the nature of the objects to be handled (replacing numbers by files) the programmer must again resort to trial and error before working out a methodology for processing the new data.

94

If instead a computer is regarded as a device for manipulating symbols according to purely syntactic rules and programming languages merely as a set of methods for elucidating these rules, clearly the fundamental problem in computer science is neither the computer nor the machine language, but the formulation of an actual situation in purely syntactic terms, i.e. the construction of a model.

It is on this account that model-building must be regarded as the basic approach in computer science.

CONCLUSION

We have attempted to show that while the processing of information is a science, it is not one which can be apprehended by merely studying the basic tools, i.e. the computer and programming languages, any more than astronomy can be reduced to the detailed study and operation of telescopes.

This does not mean that a computer utilisation course should be rejected out of hand, but means that it would be a serious mistake to imagine that computer science can be taught by this alone. The latter would merely be a technical course designed to explain the use of a piece of equipment. The question is how much importance should be assigned to such technical aspects in secondary school, which is concerned with general education.

We have emphasized the fundamental approach in computer science, i.e. model-building, which may be briefly summarised as the study of methods to solve real problems with the help of purely syntactic manipulations.

At the present stage of our knowledge computer science as such can therefore hardly be considered as a discipline capable of being taught like mathematics or geography, simply because we do not yet know whether there is a general methodology of model-building.

We do, however, have some knowledge of model-building in individual disciplines. It would therefore seem reasonable at the present juncture to confine ourselves to teaching the various model-building processes in the different disciplines when transmitting the knowledge relevant to and within some individual discipline.

This would by no means involve a revolution in teaching methods but simply call for a different approach, each fact and each new concept acquiring a new dimension through the model which integrates, clarifies and explains the fact or concept.

This approach to computer science in education closely matches that adopted in the experiment conducted during the past three years in French secondary schools under the aegis of the Ministry of Education's Information Processing Commission, directed by Mr.Mercouroff.

In the first phase of this experiment teachers from all disciplines were given a course in computer science and were asked to rethink their teaching in the light of what they had learnt in the course. The experience of a number of working parties revealed the difficulties of teachers who thus had to revise their whole teaching approach, but also showed that a number of positive results could be achieved.

The second stage was to install time-sharing systems in a certain number of schools so that previous findings could be applied.

We feel that although the cost of training teachers far exceeds the cost of the computers installed, this is the only way to ensure that the introduction of computer science in education will not become a mere gimmick or produce what the British and Americans are already calling "FORTRAN-idiots".

VIII

THE COSTS AND TECHNOLOGICAL FACILITIES WHICH TRAINING INVOLVES

by

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I should like to begin by a few remarks on the way I have presented the subject at the risk of being taxed with dishonesty in my interpretation.

The first remark concerns the sequence in which I have introduced the two operative terms. I have placed "costs" ahead of "facilities". This I feel to be important in the sense that it is consistent with the usual way in which unfortunately computer systems are chosen. In the absence of any information as to the actual tasks the computer will be required to perform, costs are often estimated in terms of available funds or, failing that, of the budget which it is felt can "reasonably" be exacted from a board of directors. An effort is then made to determine the most sensible configuration compatible with such a parameter and if it turns out to be suitable so much the better. This is a typical example of the procrustean attitude so commonly found among all types of managers, for the exercise of such brute force may well result in a ridiculously inflated budget. A striking example of this attitude is the development of the "IUT d'informatique", which are "university institutes of computer technology" much like the Polytechnic Institutes. Originally classified as properly belonging to the tertiary sector, they had very great difficulty in getting off the ground since their allocations were tiny compared with those distributed to the "IUT d'électronique" or "IUT de mécanique", which were ranked in the secondary sector (industry). Since being reclassified they have been allotted an amount of funds for equipment which is inconsistent not only with the limited proportion of computer instruction in their curriculum but also with the appropriations granted to the universities, which offer a much longer and a much more detailed course designed for a much greater number of students.

How should the word "cost" be interpreted here? I prefer to consider that this term concerns anything but the financial aspect. Otherwise we should immediately be up against the almost insoluble problem of "production costs". This is always a difficult problem, but here it becomes one of daunting dimensions when it is realised that a leading world manufacturer failed to refute an allegation officially made by an association of independent competitors, which was that the average production cost of the type of peripheral equipment generously leased out by the said manufacturer can be recouped in one month. Is it possible to quantify the development cost of a conversational system set up by a university for its teaching requirements and possibly used by other similar institutions? How is the cost of "manufacturing" teachers to be evaluated? Should it be considered negligible in all cases, or only when such an activity is occasional, the principal function being of an administrative or industrial type?

In view of the foregoing considerations, I feel it is more sensible to define budgets in terms of whatever facilities are required, without trying to express them in standard terms, i.e. money, energy, etc. We shall therefore consider a "time budget" representing the period of training personnel, a "personnel budget" defined in terms of teacher/student ratios, an "equipment budget" covering all types of systems required and distinguishing between hardware and software aspects, and finally a "relations budget" to deal with actual problems of the operational or research type. An attempt might be made to combine this last item with the first or second one, but this is believed unwise as the people concerned belong to quite a different category from that of the usual supervisory staff. This distinction may appear rather too specifically academic for a type of training provided in an industrial setting where supervisory staff are mainly drawn from "active" instead of specialised personnel. It will arise again in connection with research as soon as any kind of in-depth training is considered.

My third remark concerns technological facilities. These must be very varied. In presenting his paper Prof. Seegmüller emphasized that students might not have enough contact with computers during a university course. This is perfectly true and by no means limited to students and universities, when I think of the many programmers I have met with three to six years "experience" who had never had any contact with a machine except through the straight and narrow gate of a despatching centre or the protective "screen" of compilers, systems, and maker's manual. No doubt the greatest mistake in this field is to imagine that the problem can be solved by a "deus ex machina",i.e. the "big" time-sharing system. This can only result in setting up an even bigger smoke screen between the subject and the machine. It should also be noted that the behaviour of students or programmers who have too much contact with an over-generous time-sharing system is strangely affected. They very soon get into the habit of relying entirely on this kind of guardian angel and cease to make any effort to think and even to analyse. This has led to the proliferation of altogether spineless, largely shapeless systems which may legitimately be described as "computer cancers". Prof. Seegmüller has quite rightly pointed out that programmes of this kind cannot possibly provide suitable, i.e. usable, products.

Does this mean that conversational systems should be prohibited? Certainly not. But they must be used sparingly, in homeopathic doses, as it were. They are perfectly suitable in the earlier stages, for introducing new ideas and structures. But their use is by no means limited to the initial phase, since new ideas can be discovered at all levels of training. On the other hand they need to be used in a more normal environment and this must be done as soon as possible. A good conversational system is thus a remarkable experimental tool and should be left as often as possible at the student's disposal. There can consequently be no question of a big, universal computer except in really special cases where cost is no object. A rather curious controversy is developing with regard to the value of the IBM time-sharing operations. Experiments carried out by several of my research workers have yielded absolutely contradictory results, ranging from several seconds to several dozen minutes for the execution of original instructions. As this discrepancy was permanent and consistent for the same people, a short investigation showed that the dissatisfied parties were those using TSO "normally", i.e. as a time-sharing operation like any other warranting average priority. Their opponents who loudly championed the system all turned out to be members or affiliates of a centre which exclusively uses a big 370 machine for a permanent TSO service. They undoubtedly have a powerful tool for systems research but this kind of solution is about as economic as the famous MIT "Multics" which in June 1971, despite efforts spread over 10 years, continued to have the same point of saturation as a MAC, i.e. some 8 to 16 real users. Hence these are primarily research tools, though at a pinch they may be used operationally by customers whose time is roughly worth that of such systems (F. 5,000 to 20,000 per hour). As far as teaching is concerned they are too expensive, unnecessarily powerful and complicated, i.e. too sophisticated.

We must not forget to define the objective of this evaluation, i.e. training, whether as a programmer in the space of two short weeks, after a few months' correspondence course, or as a systems engineer. All that can be said about the first case is that extraordinary facilities would be needed for real effectiveness. As a reference we will adopt the profile defined by Prof. Seegmüller in the paper he read in October 1972. As he himself said, the profile was an ideal which any serious computer training should try to work towards. While practical training may achieve no more than a part of this ideal, it should respect essential criteria and ultimate objectives.

The first essential element in training of this kind is the time factor. Whatever the level aimed at and the skills of the persons concerned, the requisite techniques and all their implications can never be learned rapidly. Even an intensive session of one or two weeks can be no more than introductory or merely offer a refresher course in a limited field. The rudiments of a language can be learnt in several days, like the rules of some perhaps amusing but still rather arbitrary game. The algorithmic or syntactic bases required for real understanding, but which are disregarded in a course of this kind, call for a different order of mental activity and much more time for reflection. Although the bases do not have to be retaught for each language, they must be learned sooner or later and probably the sooner the better.

Programming is also a sector in which haste can be dangerous. It may of course be argued that programming is not a part of training and that it can be acquired "by practice". And yet nobody would dream of assigning a real and therefore complex problem to a programmer who had learned no more than some theory together with a few simplified and rather abstract exercises. If it is to develop properly, programming skill requires as much work, care and steady guidance as musical skill, with which Prof. Seegmüller so rightly compares it. Bad habits are as easy to acquire as they are difficult to lose.

In considering such other basic components as computer structure, computer systems, fields of application and the technical and social implications of computer science, the same conclusions would be reached. The training of a good computer specialist is a matter of years, not months. Does this mean that computer personnel cannot effectively work before the age of 22 or 23? By no means, since conventional training of university or similar type is not the only possible solution. Depending on the circumstances, a "time budget" of three or four years may be used in many different ways. Annual or semi-annual periods may thus be alternated between training and practical applications. Training and employment can also be associated more closely on a temporary or permanent half-time basis. This scheme has been tried by a large number of students of the "Institut de programmation" and the results have generally been very satisfactory: both types of activity favourably interact, with little or no increase in the duration of studies, together with practical programming experience in one or more types of application.

While for training at intermediate level the time allotted might be shorter, the equivalent of at least one year is likely to be required.

To this "time budget" must be directly associated a "personnel budget" representing necessary teaching staff. The teacher/trainee ratio is not essentially different from the usual figure in other disciplines, i.e. practical classes and tutorials of 15 to 20 and lecture groups of 100 to 150. Classes could of course be conducted for 300 or 400 trainees in an amphitheatre, but two-way communication would be largely impossible. This is also true for practical classes and tutorials, where the figures mentioned must not be exceeded. Otherwise the teacher will end up by doing all the exercises on the blackboard instead of actually checking the individual work of his students, with particularly disastrous results for programming. The same problem arises in regard to projects, which become the main activity of students from the third or fourth month onwards. At that stage the teacher's threefold task is to advise, monitor and correct the student, so that he can become proficient in the art of programming as well as in analysis techniques. This requires a teacher/trainee ratio of 1/5 or 6 in university-type courses of 15 to 20 hours per week. The ratio must of course be higher in intensive courses of the type provided in French engineering schools. An attempt may be made to reduce the size of this budget by using computer-assisted instruction techniques, which are now being widely tested in universities and industry. As these experiments show, the systems take so long and are so difficult to develop that the most likely way of achieving economies is to institute continuing types of training over a considerable period of time and over a considerable geographical area. An easier balance may be struck in the next few years as the cost of processing equipment decreases and conversational systems suited to these techniques are improved.

This is of course not the only way in which computers can be used to train computer personnel. They are an essential tool for practical work in conversational or batch-processing modes. In both cases they are of considerable help to the teacher in that they directly monitor gross syntactic or semantic errors. They cannot however replace the teacher since such errors are but a minor aspect of the programmer's art. While a simple algorithm can be represented by dozens of FORTRAN programmes, all perfectly correct syntactically and semantically, they generally include no more than one or two "good programmes" which can be performed two to ten times faster than the others. For a complicated algorithm there may be tens of thousands of different programmes and the time ratios between them may exceed 100. Determination of the optimal programme is a more difficult process and depends on the structure of the compiler and object computer. It should also be noted that the optimal programme from the standpoint of execution time is almost never the one written in the most elegant and concise terms. The situation is even more difficult in the case of programmes written in assembly language, owing to their volume and the wide latitude given to the assembler.

What can we say about the choice of computers? In batch processing, which is the main activity of trainees, a medium-size machine is needed at the outset. Its size is determined by the daily number of jobs it has to perform, which may be set at 0.5 to 2 per trainee, depending on the time of year. Execution time is generally quite negligible compared with the time required to restart the system. On this point a very humorous paper was read by Prof. Michelson at the IFIP Congress in Edinburgh. The only exceptions are simulation programmes, certain numerical analysis and operational research programmes. On the other hand, the volume of print-outs is always very substantial and justifies a certain amount of over-equipment for this purpose. The volume of punched cards can be considerably reduced by means of programme storage and editing. This also leads to a certain economy in print-outs, but the necessary storage equipment must be carefully evaluated. In any event, the essential factor is an excellent operating system and good compilers. The quality of compiler and assembly diagnostics may be a decisive factor of smooth operation by considerably reducing the number of runs needed to test a programme as well as shortening the work of the personnel.

The computer used for batch-processing need not be of any specific type, and a few hours on a big machine are quite feasible. A few runs a day will suffice to facilitate the work of the students, but any excess should be avoided since students may be discouraged by too hot a pace from analysing the diagnostics carefully enough to benefit from the next run, and this tends to increase the number of tests unnecessarily. When the number of students is small it is quite possible to use a heavy remote terminal connected to a big computer and even manage it on an open-shop basis.

We have already said that the conversational mode should only be used during three or four weeks for introducing each of the main programming chapters, i.e. machine code, assembler, various languages, systems, and for research. The only exception is of course when persons are being trained to work systematically in this mode, but these can only be users. It was also pointed out that big conversational systems should not be used. A question is whether the medium-sized computer used for batch-processing can also be operated in the conversational mode. This is not impossible, particularly if training is the sole object. In that case work can be performed on a scheduled basis, and the modes are used alternatively. Otherwise, and particularly if in batch-processing the time of some big machine is shared, it is preferable to have a low-powered, independent conversational system. Built up around a single-disc minicomputer, these systems generally have 8 to 16 terminals which can all be used at once, together with one or two conversational languages. They cost between F. 500,000 and F. 1 million. Simpler systems limited to 8 terminals and often working with a single language are even cheaper (F.10,000 to 300,000). Integrated microprocessors may soon enable even cheaper specialised systems to be developed. One attractive solution is to use a minicomputer as the high-speed satellite of a big remote system by connecting terminals to the minicomputer so that the remote system can be interrogated on a time-sharing basis. This provides a third mode in which the minicomputer operates as a concentrator of messages between the terminals and the central RJE (remote job entry) system.

These two chapters do not cover the whole "equipment budget". Audio-visual techniques might be of considerable assistance in computer training if usable documents were not so rare. The main factor in this sector is the specialised equipment for practical work designed to facilitate the teaching of computer structure. This training is important for all computer personnel and essential for those specialising in systems design. Equipment in this instance largely consists of models for simulating the operation of various parts of the computer, from logic elements to whole units. The basic equipment makes it possible to view the main methods of storage and information transfer and to synthetise the operators concerned, i.e. flip-flops, registers, different types of link, buses, memories and arithmetical operators. The system used at the "Institut de programmation" is based on a cold cathode thyratron acting as a logical element and also as a viewing element. Other systems enable the detailed static and dynamic operation of logical elements and the exchange mechanisms between the processor and the peripheral units to be studied experimentally. Each of these systems costs from F. 20,000 to F. 30,000 for a practical workshop designed to accommodate 15 to 20 students at a time.

The "relations budget" is much more difficult to calculate and even to specify as it largely depends on the environment and on the computer activities of a practical or research kind which are performed. It plays an important part in connection with the systems projects and specialisation.

In concluding this evaluation, every ten students may roughly be said to require two teachers and computer specialists, a computer worth F. 40,000 to F. 60,000 or an equivalent sum for hiring a computer (up to F. 1,000 per month) and special equipment for practical work costing from F. 1,000 to F. 2,000. This evaluation is valid only for fairly big student intakes (100 students at least). The figure will be higher in the case of smaller intakes. In any event a comparison between these figures based for example on the payment of an average remuneration of F. 3,000 per month to teachers shows that the "personnel budget" is by far the predominant factor. While the "time budget" is particularly difficult to evaluate, it appears to be greater still.

IX

CAREER PROFILES IN EDP

by

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INTRODUCTION

Is there a career in EDP? An attempt has been made to answer this question on different occasions, but EDP still seems too young to be able to offer a totally structured career. Furthermore, in many enterprises the EDP department can offer a means of promotion within the firm or be a stepping stone to management.

Many enterprises are struggling with the manpower problem associated with the arrival of the computer. Even those well established in the field have to undergo changes in job structure and description owing to the new hardware and software. And it should be remembered that the EDP jobs in a small data processing centre are unlike those in a medium-sized, not to mention a large, unit.

HOW PEOPLE CAME TO WORK IN EDP

Although this question might seem irrelevant, I believe that even a brief look at it will help to explain how existing situations have arisen.

The background is that staff were recruited to EDP from within the enterprise. They were trained, at least in the beginning, by the firm selling the computer or actually in the computer firm itself. Because the computer was unfamiliar at the time, and such an expensive machine had to give a maximum rate of return, high salaries were offered. This implied from the very beginning that EDP jobs offered a means of promotion for staff from other parts of the enterprise.

Since programming (here I take the word programming in its widest sense) and operating needs were growing faster than the number of people who could be recruited and trained within the enterprise, hiring already trained programmers and operators became the habit in recruiting EDP staff, leading to a real spiral in salary levels, without improving or having any effect on the quality of the work being done.

The recruitment of trainees from EDP schools has only recently started and the results are yet to be seen, but until the turnover is higher in the EDP departments, staff do not come from other parts of the enterprise. The problem is simple, that there is less movement among the staff when there are career possibilities.

But before going further we must distinguish between EDP managerial and EDP non-managerial jobs, the latter being mainly technical and the former supervisory. The requirements and training qualifications for EDP technical jobs are usually clearly defined in most of the available standards, or company job descriptions, but this is not the case for supervisory and managerial posts. Here too often the computer myth has not yet disappeared and more attention is paid to technical skills than to managerial talents and knowledge. Training an EDP technician for a management position within the EDP department is too often neglected. It should also be borne in mind that a good, or even excellent systems man is not necessarily a successful project leader, or an experienced senior programmer might not be most suited to be a programming supervisor who could later be trained for EDP management.

EDP AS A CAREER WITHIN THE ENTERPRISE

If EDP is merely regarded as a new department in the enterprise to which employees may be sent on promotion, thence moving to other parts of the enterprise, then the EDP career pattern can be very interesting. I will try to explain why this is so.

If recruits for EDP come from the rank and file in the enterprise they are presumably going to be properly trained: but this is not our point. They may enter and leave EDP at different levels.

Where are the EDP entry points? There are clearly four main points: a) operations (machinery operator and data control clerk); b) programming (entry point at lowest level); c) systems analysis (entry point at lowest level) and d) EDP management. Let us take a look at each entry point.

a) Operations

At this entry point in EDP there are two types of activity:

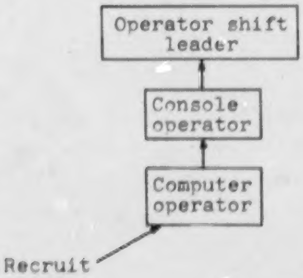
i) Machine operations and

ii) Data control.

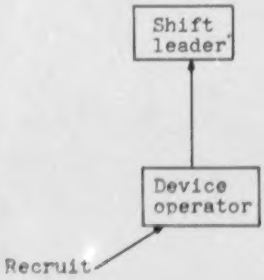
A clerk in the firm can easily be trained to become a computer operator and a typist to operate a data-input device.

An EDP career can be launched from these points more or less on the following lines:

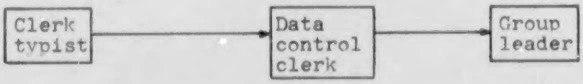
Computer operations



Input device operations



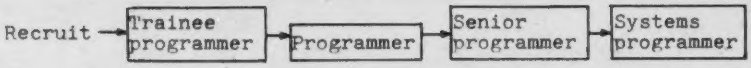
As in machine operations, a clerk or typist can enter EDP at data control level. Training offers no difficulty, although there is advantage in recruiting staff from the departments whose own data are to be handled. The career in this case is marked by no special pattern:



This leads to the obvious question as to why computer room, data collection and data control management and supervisory jobs should have been omitted from the career pattern. The reason, I believe, is that managerial skills can be at least as important as technical skills for these junior management posts, since managerial skills require special training and so enable the employees concerned to pursue their career within the enterprise: but outside EDP. Here we find an exit point from EDP. At the same time, junior managers can occupy these positions successfully without much EDP experience or training.

b) Programming

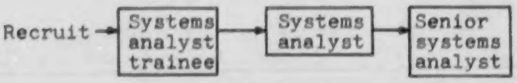
Here we have a similar situation to the one explained above. Employees coming from clerical and technical jobs (and, of course, computer operators) can be trained in programming and so enter EDP. The career pattern may be as follows:



Again, managerial positions in programming are considered to require special training in management skills and this can open up career paths outside EDP or in EDP management.

c) Systems analysts

This is an interesting entry point into EDP for staff who have reached a certain level in the enterprise. In my opinion, these experienced employees can, with proper training, become the most able systems analysts. They usually have sufficient knowledge and experience of the enterprise to enable them to take the right decisions in applying EDP solutions to the firm's problems. The career path for them could be:



Again, jobs that require managerial skills such as project manager, team leader, etc., call for proper management training and this will of course open up new career paths in the enterprise.

d) EDP management

The management of EDP functions is of the utmost importance, and there is growing agreement that it should be in the hands of managers rather than technicians.

Accordingly, I believe that the different EDP functions which we have mentioned so far can be managed either by EDP professionals trained in management techniques or by managerial staff of various grades trained in the basics of EDP. I prefer the latter. Hence these could enter EDP as computer operations manager, data collection manager, programming manager, systems analysis manager, project leader or EDP manager. And their managerial position in EDP can be regarded as any similar position within the enterprise. They can leave EDP in the same way as they came; though of course a possible career path in EDP management could be as follows:

Computer operations manager	Programming manager	Systems analysis manager	EDP manager
Data collection manager	Data collection supervisor	Programming supervisor	Project leader
Data control manager	Data control supervisor		

All these positions would of course require EDP technical training at different levels, but the main item to be considered is management expertise.

EDP AS A CAREER IN ITSELF

If we consider EDP as a career in itself, disregarding its environment, the career paths can be different from those described above. Assuming that the lowest entry point in EDP is data control, a clerk in data control could become a data collection operator and from there move up to computer operations.

A shift leader computer operator would become a programmer, and once he was a senior programmer could move into software.

Entry could, of course, be at any of the career levels, but within the career itself training at each step is required.

Furthermore, a question always raised is the fact of making a life-long career at one level and becoming a real expert. It is difficult to generalise on this point since the situation and terminology differ from country to country. For this reason I shall not try to go into the various jobs or posts within one given EDP function. Neither shall I take into account any such auxiliary task as that of librarian, planning clerk and dispatcher.

It can be said from experience that machine operators (computer operators) do not think of the job as a closed career, but (through training, of course) either become programmers or leave the EDP department. The situation is different with data collection operators who are usually women and who quite often only leave for marriage reasons or because they succeed in becoming shift leaders or supervisors.

Programming is another matter. If we consider programming as not just coding but developing programmes, we might think that it could well become a lifelong career. Beginning at programmer trainee level, a programmer through further training and experience can acquire the sort of unique expertise leading to consultancy posts in the programming field. And if he goes into systems programming, then he finds boundless career opportunities. It should not be forgotten that many programmers by vocation like programming for itself, so if the salary and working conditions are suitable it can become a lifelong career.

As regards career opportunities in systems analysis, it is not easy to fix a pattern of behaviour owing to the very nature of this function. There are many cases, mainly of staff who have reached this level in their EDP careers via programming, where it might be the culminating point of their career. But if they enter EDP at this same level via other areas of the enterprise, they will probably return to the general pattern in their firm.

Finally we come to the EDP manager. As we have said before, he had better be a manager rather than an EDP professional. While this may sound heretical to some colleagues, experience shows that unless the EDP manager is trained in managerial skills, no matter how great his EDP experience and knowledge he will fail in his job.

CAREER OPPORTUNITIES

When discussing career paths we must also bring up the problem of career opportunities. Here the size of the enterprise and the subsequent size of its EDP department are essential factors.

We can for our purpose divide enterprises into three groups according to size. As a rule, we consider that the size of EDP activities is in proportion to that of the enterprise.

The large enterprise which is able to make use of sophisticated EDP applications in many cases offers a complete range of EDP careers, both on the technical as well as the management side. The EDP professional can then plan the different steps in his career since some of the jobs are highly technical.

The medium-sized enterprise offers a limited career opportunity, mainly because of the number of EDP posts offered. Quite a few functions may be combined in one post. From the purely professional aspect the possibilities of applying technical or managerial skills can be considered to be similar to those of a large firm, but not from the standpoint of promotion.

When we come to the small organisation we find ourselves in a situation where the career path is reduced to a minimum, not only are few EDP posts offered but usually the professional skills required are not particularly advanced.

CONCLUSION

From the above account it can be seen that there are two main lines of career path in EDP, one technical and the other managerial, with a branch line towards systems analysis.

The career paths can be shorter or longer, depending on the size of the EDP department in the enterprise.

Lastly, I wish to make it clear that the job description terminology existing at the present time can be rather confusing since similar designations have different contents, and vice versa.

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X

RECURRENT AND PERMANENT EDUCATION AND TRAINING

by

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We will limit the problem of computer manpower retraining and continuing training to some major functions for which basic courses now exist in Europe. The retraining of persons who have already received basic training will primarily be dealt with.

COMPUTER FUNCTIONS

Taking data processing in management as field of reference - the special field of numerical data processing is left aside in the following study - we shall describe certain major functions, dividing them into two groups:

- problem oriented functions;
- functions dependent on computer techniques.

In the first group we will pay particular attention to the systems designer and analyst, and in the second to the computer designer, systems programmer and programmer.(1) The functions are classified on the assumption that the logical approach - problem oriented applications - is entirely independent of the computer approach regarded from a technical standpoint. The logical approach aims at creating an information processing system, whereas the technical approach is concerned with setting up a computer system.

The object of this separation is threefold, namely:

- to see that a particular application is not rigidly fixed, whether structurally or operationally;

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1) We will not deal with functions originating from these basic functions (e.g. computer centre managers) or the more elementary jobs of console operator, operator, etc.

- to save on programming by setting up standard components;
- to encourage the proper use of skills.

Since the difference between the user's and the computer scientist's standpoint involves a modular approach, the modules defined during the design and analysis stage and those which are created during the programming stage must be interrelated. This intermodular connection actually amounts to one between two nomenclatures:

- the first associated with a structure considered from the aspect of an information processing system;
- the other associated with the engineering components of a computer system.(1)

Systems Designer

He is responsible for thinking out an application as part of a system in terms of data processing possibilities and constraints and the effectiveness expected from the solution. This will mainly consist in changing operational procedures and management methods, generally by defining computer-based solutions, adjusting organisational structures, specifying training programmes and analysing these various elements from an economic standpoint.

The applications will be envisaged in the context of a management data processing system, i.e. a computer system regarded as logistic support for integrated management.

Systems analysis will be the methodological basis for the systems designer's approach.

The ideal profile for the systems designer would be that of an engineering or university graduate with a genuine practical knowledge of data processing, management systems and organisational problems in addition to his thorough experience in the applications to be handled.

His computer training should at least include the following: training in the logic of EDP units, some knowledge of a programming language, thorough acquaintance with the organisational structure of files (basic and complex structures), and an advanced course in the theory and practice of analytical methods.

Systems Analyst

The systems analyst is regarded as assisting the systems designer. His particular task is to prepare certain specifications, describe in detail the functions to be computed, logical records, print-outs, etc.

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1) See Annex.

Training for this work is given by universities and engineering schools which provide a computer course supplementing the basic applications oriented training (engineers, economists, specialists in applied mathematics, physicists, etc.). His grounding in computer subjects would be similar to that of the designer.

Computer Designer

His role in the field of computer techniques is similar to that of the systems designer, with whom he is in constant communication. His particular task is to analyse the choice of:

- computer system;
- operational system;
- software (programming languages, compilers input methods, file organisation, etc.).

He must define new basic software items (languages, analytical tools, functional changes in the operational system, etc.) and must specify the requisites for introducing some new application or set of applications.

This function requires a thorough training in computer science, one which is adequately applications oriented. Specialised computer science courses in universities (such as engineering or master's degrees in Computer Science) aim at providing this type of training. Emphasis will be laid on the need to combine a basic course (theory of languages and systems) such as to promote the student's adjustment to a constantly changing field with enough practical knowledge so that he can construct the base of reference needed for effectively learning the abstract side.

The general function of computer designers or computer scientists includes more highly specialised tasks, conferring the role of an assistant similar to that of the systems analyst in relation to the systems designer. Among these functions may be mentioned that of the systems engineer, an expert dealing with operational systems whose job is to make the best use of an EDP system to advise the designers, analysts and programmers.

Systems Programmer

The systems programmer, sometimes also described as a systems analyst, using a solution which has been planned in every detail both from the applications aspects and that of the data processing method adopted, prepares the file to be used by the programmers. He breaks down the programme into routines, prepares the flowcharts, test data, etc.

The basic training of systems programmers is given in lower technical education. The good results obtained in France and Belgium through the medium of the University Institutes of Technology and university courses in Computer Science are particularly worth mentioning.

Programmer

Since several programming languages have to be mastered, as operational systems are becoming increasingly complex and equipment and applications are continually developing, the job of programmer requires intensive and thorough training. It is similar to that for systems programmers, promotion to this function depending on experience.

RETRAINING: FOR WHOM?

We will only consider the question of retraining persons who have already received basic training. We will not deal with the question of the rehabilitation of such "misfits" resulting from the disorderly growth of computer education as self-styled analysts with no real training in computer science, incapable of planning new approaches in computer terms, or programmers with no methodological grounding and only acquainted with a single language, machine and problem.

CONTENT OF RETRAINING

An attempt can be made to define the content of retraining in terms of the growing pains of EDP and the foreseeable medium-term development of data processing systems.

A major growing pain is the economic analysis of data processing. Many businesses feel that the computer is not being used to full capacity. Among the reasons may be mentioned:

- shortage of competent staff;
- the absence of any real analytical and programming methods, such as to reduce the time required for writing, testing and maintaining programmes as well as the cost of adapting and developing applications and programmes;
- the lack of integration in systems design, which means that applications are rigidly fixed or must be designed all over again;
- the difficulty of assessing the effect of a computer solution on the associated organisational system and costs;
- the cost of certain basic software such as OS and IMS;
- the shortage of universal devices for measuring a system's performance and optimising a configuration.

These deficiencies chiefly reflect the relatively disordered growth of ADP and the lack of any mental approach - even among the specialists - consistent with the inherent possibilities of computer systems.

We will describe various trends which can be foreseen over the next few years, such that the conditions for carrying out the functions mentioned above will be changed.

It is reasonable to suppose that in applications design the integrated approach to problems featuring the use of systems analysis techniques and methods will be extended, that heuristic processes will be substituted for algorithmic processes, and that broad models for checking and control will be established in preference to those which cannot be fully optimised.

The expansion of integrated management systems influenced by the expected development of:

a) analytical and programming methods marked by the increasingly modular and automated phases;

b) certain computer techniques:
   - methods and techniques of data retrieval (optical character recognition, pick-up devices connected to analogue and digital converters, etc.);
   - the organisation of data banks, in which security and search-language problems will be dealt with.

In the case of integrated data networks techniques for interconnecting computers may be mentioned. From a technical standpoint, the development of micro-programming methods (such as dynamic micro-programming) may moreover be pointed out.

Lastly, as regards basic software, the following may be mentioned:

- programming language research, such as in regard to self-expanding and self-checking programmes;
- the development of compiler techniques (transferability);
- a greater knowledge of operational systems, particularly the formulation of functional models, the gradual working out of theory and the definition of performance indicators;
- the definition of standards for software.

RETRAINING: BY WHOM?

It will be noted that persons now acquiring basic training in universities for the jobs described above do not possess any adequate knowledge of most of the subjects mentioned. In view of the unbalanced instruction they receive, we feel that retraining should not be confused with the general information distributed by manufacturers and software firms.

We suggest retraining in depth so organised by universities and research centres as to teach the fundamental aspects of computer science and also promote exchanges of experience .(1)

Such a formula would have the advantage of:

- supplementing and balancing the basic obsolescence;
- providing participants with the required technical knowledge to make a retraining session worthwhile to their enterprise at short-term;
- confronting universities and researchers with problems encountered by practitioners.

This type of confrontation should influence the orientation of research work, promote the association of practitioners with research activities, and encourage really dynamic research. Retraining in depth should also facilitate changes in fields of study and limit overspecialisation, involving not only changes in technical computer functions but also changes over to the applications field (systems designer and analyst functions).

TRAINING OF USERS

For the field of computer applications to be expanded and their quality improved, neither growing numbers of qualified experts nor increasingly efficient technical resources are enough - the users must moreover be computer-minded. The particular characteristic of this state of mind is the capacity to think out a problem in terms of computer possibilities and to make a detailed logical analysis of an application for processing by computer.

For users to acquire this capacity means that they must look upon the computer as more than a mere tool. Learning a well-structured algorithmic language or preparing and reading a flowchart will not be enough to cause any substantial change in their working methods. Acquiring a computer-minded approach calls for an awareness of the new potential offered by EDP systems:

- integrated data processing;
- man-machine communication;
- definition of heuristic retrieval procedures with machine learning;
- creation of simulation models;
- increased control of the information flows associated with various feedback levels;
- establishment of new networks for transmitting information; etc.

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1) For example, the seminars and schools organised by the IRIA.

It would therefore be advisable to base introductory computer programmes on heuristic rather than the algorithmic approach. We feel that the use of computer-assisted learning methods and original computer-teacher applications would be more effective than some of the present solutions (general description of computers and elementary programming courses).

CONCLUSIONS

We have set out in this very short note a few principles which might be used for initially defining a programme to retrain certain computer specialists.

This introduction should be developed:

- by studying concrete methods for implementing these principles;
- by extending the analysis to other functions.

We would point out that we have not explicitly tackled the question of continuing education but dealt with it through the bias of retraining users.

Annex

NOMENCLATURE USED IN A DATA PROCESSING SYSTEM(1)

NOMENCLATURE FOR PARTS OF THE ENTERPRISE CONSIDERED AS A DATA PROCESSING SYSTEM

System

In drawing up a project, from a data processing standpoint the scale of the organisation has to be taken into account. Example: enterprise, establishment, production division within an establishment, ministerial department, section of a ministerial department, VAT system, system for tax recovery.

Sub-system

An organisation may be broken down into sub-systems - the first level in the hierarchy of a system - according to different criteria:

- geographical location,
- types of activity,
- type of basic functions (e.g. departments concerned with marketing, finance administration, production, personnel, etc.); or
- a combination of these criteria.

Main criterion used for defining a sub-system is the sort of homogeneity ensuring close integration between execution and management procedures.

A sub-system may be broken down into applications.

Application

An application is a set of homogeneous activities carried out in the framework of a sub-system. The quality of homogeneity is mainly achieved through continuity of the activities in time.

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1) Cf. F. Bodart: "Cours d'analyse de systèmes informatiques", /Analysis of data processing systems/, Institut d'informatique des facultés universitaires Notre-Dame de la Paix, Namur.

An application may be broken down into "phases".

Example:

Two applications may be distinguished within a "personnel" sub-system:

- "wages and salaries",
- "personnel management".

The first of these would include the phases of:

- maintaining personnel records,
- calculation of gross pay,
- calculation of net pay,
- quarterly statements,
- annual statements.

These different phases involve continuity in time at the logic (sequence of phases) execution and planning levels.

In the second case, the phases might be:

- day-to-day personnel matters,
- budget forecasting,
- analysis of allowances,
- recruitment,
- preparation of training programmes.

Continuity results mainly from the overlapping of the different phases.

Phase

A phase is a component of an application characterised by unity of execution in time and in space.

Unity in time : this is based upon initial information or information obtained from phases carried out earlier; it produces either final information - in the framework of the application - or information intended for subsequent phases.

The phase is executed at fixed (e.g. calculation of net pay) or variable intervals (e.g. stock control in a permanent inventorying system).

Unity in space : this is achieved owing to the fact that a phase is executed within an "activity cell".

An application may be regarded as a graph in which the peaks are the tasks and the curves correspond to the sequence of events between tasks.

An application defines an ordering of tasks.

The phase and its dual notion of activity cells are key items in the nomenclature: they are the factors used for defining units of information and the processes to be applied to these.

Function

A phase defines a set of functions to be carried out. A function specifies a series of basic operations to be applied to the information. With each function is associated one or more operations which, when applied to the input information, produce the output information.

Example:

Calculation of VAT when preparing an invoice is a function.

To illustrate the relationships between phases and functions, we shall take the example of the "calculation of gross pay" phase. It can be broken down into a set of functions comprising:

- calculation of gross pay for normal working hours;
- calculation of gross pay for overtime;
- calculation of gross pay relative to bonuses;
- calculation of gross pay relative to benefits and other extra payments.

This phase is developed from the results of the previous phase "updating of personnel records" (recording of variable components, modifying permanent components).

The result of this phase will be used as initial data for the "calculation of net pay" phase.

Each function involves a processing algorithm.

The breakdown of a phase into functions is arbitrary. It may simply be said that a function represents a homogeneous and significant process applied to a set of information units.

Basic operation

This is the lowest level of the nomenclature. A function is broken down into basic operations such as : updating a document, printing a document, copying a unit of information, calculating a square root, etc.

NOMENCLATURE IN THE "TECHNICAL" COMPUTER SYSTEM

This second nomenclature is proposed for computer techniques such as: operating nodes, file structures and methods of accessing data, organisation of processing and programming.

With each level of nomenclature will be associated significant components from the standpoint of computer techniques.

NOMENCLATURE OF COMPONENTS OF COMPUTER SYSTEM ASSOCIATED WITH THE ENTERPRISE(1)

System

To the system will be basically associated the files (sets of information units) defined at this level. In the main these will be personnel (identification) files and record files.

Sub-system

As at the preceding level, the significant information units will be defined for this entire sub-system. They will mainly concern personnel (identification) files, record files and situation files (defined at sub-system level).

Application

In computer system, an application will be considered as a coherent and self-contained set of operations and files.

These characteristics arise from the following aspects:

- Cohesion: intense circulation of information internal to the application,
- Autonomy: in principle no information circulates between two different applications, except possibly for certain original primary information, but without any return to the application from which they were taken (e.g. selection of order forms and invoices from "credit management" to "accounting"; subsidiary files from "wages and salaries" to "personnel management").

[illegible]:

[illegible] [illegible]:

- the different types of files (transfer, operations, identification, situation and record files),
- the flowchart showing the links between these files,
- the interfaces with the other applications.

Procedure

The procedure possesses operational unity due to its uniformity

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1) Cf. A. Clarinval: "Méthodologie de la programmation" /Programming methodology/, Internal Paper, Institut d'informatique des facultés universitaires Notre-Dame de la Paix, Namur.

in time; it can therefore be introduced as a single "job" for processing on the computer; it is handled in a single run from the point of view of the operator. Each procedure has its own frequency, which is either fixed (e.g. preparation of invoices + transfers + bills = "invoicing" procedure) or variable (e.g. updating identification files).

Example:

Input of transfers (with checks, inventories, etc.), preparation of invoices, production of daily statements (daily budget and daily cash statement) or monthly statements (ledgers).

The idea of procedure is equivalent in the IBM 370 operational specification to "catalogue procedure".

Note:

Several categories of procedure can be distinguished:

- "construction" procedures of the sub-system or application, i.e. those which alter the information stored in the system; they of course include all necessary "identification" (print-out) aspects; it is often possible to schedule their frequency;
- "identification" or "print-out" procedures, for example, "print-outs" on request, which do not alter the information stored, i.e. they must be entirely specific and can incorporate specifications, such as print-out sequences, that are specific and capable of being expressed in parametric form for implementation; such specifications are not used in the "standard" print-outs of the construction procedures;
- "[illegible]" procedures (e.g. copying files, programmes, procedures) and "[illegible]" procedures (e.g. reconstruction of a file from the "back-up") [illegible] as possible;
- operational maintenance procedures (e.g. a programme for calculating the amount of space a file requires on a disc, for analysing the state of the file — percentage overflow records, etc. — reorganising the file, managing the file catalogue, and so on);
- procedures for building up and maintaining software (writing programmes, maintaining libraries, etc.).

Function

Examples are : reading a file, consulting a file, writing a file, sorting a file according to a given sequence, checking some item, generating or formatting an item, printing out a statement.

The function is one process applied to an item in a procedure (or a programme - see below). *A single* process applied to *one item* can of course consist of several separate operations applied to many components of the item (e.g. checks on zone validity).

In addition to the *logic functions* defined in the non-technical nomenclature, there will be other functions specific to computer nomenclature such as tape rewind, calculation of a "check digit", accessing data in a given medium, etc.

The function will be executed by an *operator*. There are three different types of operator:

- *processing* operators, executing a function;
- *structural* operators or logical records, providing the link between the processing units;
- *parameter transfer* operators.

The operator, if it is to work and perform some concrete function, must be updated or parametrized (there are several techniques: parametrization itself programmed, use of a parametrized macro-instruction, communication of parameters to the different units in the form of arguments).

CORRESPONDENCE BETWEEN THE TWO NOMENCLATURES

Organisational nomenclature		Computer nomenclature
System	↔	System
Sub-system	↔	Sub-system
Application	↔	Application
Phase	↔	Procedure
Function Basic operation	↔	Function-operator

The relationship between the two nomenclatures is shown in the figure.

We have kept the same names for the three upper levels since the computer aspect introduces no new element.

However the data processing approach does generate elements which appear neither in the phases nor in the breakdown of the phases into logic functions (processing functions).

XI

IMPACTS ON SOCIAL STRUCTURES CONSEQUENT UPON THE INTRODUCTION OF TRAINING FOR COMPUTER SCIENCE INTO THE EDUCATION SYSTEM

by

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INTRODUCTION

The growth of application of computers has had a profound impact on our social structures and on our ways of working within those structures. We can trace the changes in economic and social structures due to various applications of computer technology. In the United States, for example, we have moved into a post-industrial, service oriented economy which is supported and strengthened by computer technologies.

There have been efforts over the past few years, of varying degrees of success, to introduce the fundamentals of computer science and the principles of computer applications to the individual in order to prepare him to take full advantage of the potentials of computer technology. The extent of the successes, or the failures, can be seen in the attitudes of the individual on computer utilization in his society. Based on the realization that more must be done to acquaint the citizen with the potentials of computer science, it is necessary to continue exploring various approaches toward introducing the concepts into our educational system and to the adult consumer.

As the citizenry becomes better acquainted with the world of computers, we should be able to see a change in attitude and a change in appreciation for the place of computers in our society. Knowledge of the ways in which computers operate will help to shape the intellects of our citizens, to permit man to adapt better, to learn how to handle information and to select data, aided by the potentials of computer technology.

DEVELOPMENTS IN ECONOMIC STRUCTURES

There is little doubt today that the computer is becoming a major technological device in many of the broad areas of social and economic development. Computer technology represents one of the most remarkable growths the world has ever witnessed. In the past two decades, the number of computers in the United States alone has grown from zero to over 100,000 - that is one computer for every 640 families! In the rest of the world, the number of computers has risen to nearly 50,000. In applications "from health care to defense, education to crime control and biology to physics, computers have ... proven their ever expanding effectiveness." (1)[*]

During this same period, technological developments have led the United States into a post-industrial society, characterized by a service oriented economy. By the mid-1950s, more than half the population of the United States was gainfully employed doing something for other people rather than in either manufacturing or agricultural pursuits. Today, more than 63 per cent of the United States labor force is employed in the service industry. By 1980, statisticians predict that 2 out of 3 members of the labor force will be part of the service sector.

The technologies integral with a service economy and essential to achieving its goals include computer technology, communications technology, and information technology. They serve to link users, services and products in a meaningful and efficient way. Computer networks, the means to accomplish this linking, "could well be the strongest force at our command today" for improving operations in industry, in education, and in government.(2) Computer networks are essential for real time, geographically dispersed control activities vital to a nation's well being, such as in the transportation, financial, and retail trade areas. Computer networks make possible the sharing of information resources, computing resources and information handling equipment, including library, census data, medical insurance and social security files. Computer networks ensure equality of access to and quality in public services, such as law enforcement, educational facilities, and health care delivery.

One of the characteristics of the post-industrial, service oriented society is its dependence on information as the basis for control of its complex organizational structures. It uses information to direct its mechanisms for action and is guided in its direction and policy by information. The growth of computer applications and the switch to computer networks reflect a basic change in information handling and communication techniques. This change must include a realization on the part of every man of his own dependence on effective use of information and the need for him to adapt to the newer technologies and their application. As the citizen learns these lessons and contributes even remotely to the successful implementation of systems embodying computers, communications, and information technology, we can expect to see definite effects on the way we do business.

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[*] Figures in brackets refer to the Bibliography at the end of this Chapter.

a) Because of successful applications of computers, we see a trend towards increased centralized control of the management of geographically dispersed organizations. A hallmark of government and industry will be widespread enterprises with one central headquarters and a large number of diversified, geographically separated manufacturing or service subsidiaries. The efficiency of centralized management and decentralized operation is possible only with computer networks. Before their use, real-time management from a central location of the day-to-day operations of geographically dispersed facilities was virtually impossible. Now with computer networks and the correlative rapid transfer of selective information, retail stores, banks, and commercial air traffic, as examples, can operate effectively through up-to-the-minute information transfer. In addition, in activities where decisions must be made on the spot, management via computer networks makes local decision-making feasible while maintaining centralized control.

b) The sharing of expensive information and computing resources will become a characteristic of our social structures. There are many organizations which cannot afford to maintain their own extensive files of basic data yet need portions of such files on a daily or frequent basis. Access to such expensive equipment and information stores can be obtained through implementation of computer networks. Some areas of important scientific research still need computing power available at a limited number of sites having the largest computer installations. Most individuals engaged in such research cannot afford the necessary computing power locally, but through computer networks can have access to that power. The networks aggregate the market for computing power and supply the means for cost-sharing expensive development of increased computing power among customers.

c) The explosive increase in the minicomputer inventory in the United States and around the world acts to bring ever closer the contacts between man and machine. Minicomputers are becoming personal computing resources; linked to computer networks, they provide each of us our own individual information center. In the office or at home, we can tap a myriad variety of information resources to help us keep informed and make decisions efficiently and effectively. World news, local weather, special events, particular instructional courses or general educational reviews will be available for our choosing. Data bases peculiar to our needs can be constructed from general informational resources and maintained for use at our own convenience.

d) The characteristics and potentials of computer technology will make much of our present paperwork unnecessary and obsolete. Decisions will be recorded in individual data banks; transactions will be initiated and completed in computer storage. As a result, our operations will be more efficient, less cumbersome, less error-prone, more timely. We already see examples of the "checkless-cashless society" undergoing tests for utility and consumer reaction. Soon we will initiate a transaction, like a retail purchase and have that transaction completed, such as paying for that purchase, without need for the traditional billing procedures, checkwriting and bank account balancing processes we follow today. In the same manner, business management will produce reports in the form of computer-generated displays, which can be manipulated in response to inquiries and dialogues, in order to examine alternatives to various possible corporate decisions.

HOW PEOPLE PERCEIVE THE COMPUTER

The beneficial effects of computer applications are counterbalanced by forces of resistance to change, high costs, technological problems, and the fears and anxieties of people who are touched by them. Those involved with computer science and technology, that is, computer specialists and those who have the responsibility for fostering the utilization of computers, must serve both the producers and consumers of computer products and services. The computer profession has a special obligation for ensuring that computer technology serves the citizen in ways to enrich and improve his life while protecting his right to privacy and dignity.

Accompanying the picture of the pervasiveness of the computer are the "horror stories" so rampant today. Two of the most frequently heard are, first, that computers are replacing man and, second, that computers are dehumanizing and constitute a threat to the individual's privacy.

Studies have been made of the use and misuse of computers, and other problem areas identified with effective utilization of computer technology. The conclusion that can be drawn is that it is necessary to develop and provide enough information to consumers of computer products and services that the consumers can know what computers can do for them and what they cannot do.

In order to measure the magnitude of the problem of defining the information needed about computers, we must first recognize and measure the extent of the knowledge (or ignorance) about computers of most citizens. A number of studies have been made that seek to determine the perception of the computer and its uses held by a representative sample of citizenry.

a) An experiment which took place in a Scottish hospital was designed to utilize the computer to perform basic, repetitive tasks in order to release doctors from simple administrative chores to perform more professional duties. The first task of the experiment was to program the computer to take a straightforward medical history, according to a clear history format. Patients were divided into an experimental group and a control group. The experimental group was interviewed by the computerized system and the control group by using the traditional doctor's approach. People seemed to enjoy the computer interview. In fact, half said they preferred the computerized medical-history-taking procedure, that they felt more at ease and that the machine "was very polite and very patient". (3)

b) Another brief example took place at the Stanford Center for Research and Development in Teaching. The purpose was to determine how students feel about their experience with computer-assisted instruction. Over all, the students had a more favorable image of the computer than of the teacher. More reliable and more objective evaluation was provided by the computer learning situation than traditional classroom instruction. The almost simultaneous feedback on the quality of the student's performance was deemed to be rewarding.

c) The joint study sponsored by the American Federation of Information Processing Societies, Inc. (AFIPS) and Time Magazine took place during July and August 1971 and involved 1,001 telephone interviews with a probability sample in the United States. The eight basic areas in which data were gathered were job involvement with computers, incidence of personal problems because of a computer, the role of computers as perceived by consumers, people's image of computer usage in business and government, the general effect of computer usage as perceived by the individual, attitudes toward career opportunities in the computer field, and the relationship of computer usage to privacy. It might be of interest here to review selected data from among the overall results:

i) About a third of those surveyed reported that they have had a problem because of a computer; billing problems were the most frequent causes of difficulties. The majority reported they have never had problems in having a computerized bill corrected. Of those who did have difficulty, most blamed the personnel of the company involved rather than the computer itself.

ii) The public view of the use of computers in providing consumer benefits is generally positive. Nearly 9 out of 10 surveyed felt computers will provide many kinds of information and services to us in our homes; more than 6 out of 10 felt computers are helping to raise the standard of living, and have helped increase the quality of products and services. However, the same ratio of respondents felt the use of computers in sending mail advertisements to the home should be decreased.

iii) In general, the public believes government should make increased use of computers in a number of areas, that such usage will make government more effective, and that there should be increasing governmental concern for the way in which computers are used and about regulating such use.

iv) There is major concern about the use of large computerized information files. More than half of those surveyed are concerned that some large organizations keep information on millions of people, and that computerized information files might be used to destroy individual freedoms or to keep people under surveillance.

v) Of those surveyed, about three-fourths were in favor of a young person entering the computer field as a career, and saw the jobs as interesting, challenging, and offering rapid advancement. They also believe such careers require lots of training.

d) A study done for the Federal Department of Communications (Government of Canada) by the Social Survey Research Center in Toronto, involved a qualitative study to elucidate the issues concerning the public's perception of computers and computer services, and a quantitative survey to evaluate the feelings and reactions of a cross-section of Canadians (1,030) on the basis of a questionnaire. About 85 per cent of the total number of respondents indicated that they had either a direct or indirect contact with a computer. In terms of perception or image of the computer, most thought of it as a very efficient mathematical machine. Slightly over half of the respondents perceive the computer in a beneficial way in terms of enabling government and business to make better decisions, and of improving the quality of education. Nearly three-fourths agree that computers will provide far more leisure time.

On the other hand, almost three-fourths of the respondents thought that the computer would cause unemployment. Although the perception may not be real, i.e. the computer may not cause unemployment, the consequence of the perception becomes real, i.e. people fear the introduction of the computer, particularly in the work environment.

Studies of this nature point to three major conclusions. First, to most people the computer is becoming the overriding technical symbol of the 20th century. Yet there is probably little awareness of the technical complexity of the device. In addition, many people express two sets of conflicting attitudes about computer technology: they appreciate the benefits derived from computerized systems in terms of medical, scientific, and technical progress, yet they express considerable hesitation about what the computer will actually do to them in terms of interpersonal relationships and their day-to-day activities. Finally, even given the traditional limitations on survey research data, there exists a growing body of empirical data on which more objective decisions can be made concerning the psychological and sociological dimensions of computer technology. What is needed is further research to increase our understanding of the human impact of computer technology.

POSSIBLE SOLUTIONS

Given the burgeoning role of the computer in today's world, and the current perception of that role by the private citizen, how can we provide for the education of that citizen? How can we teach the individual to adapt to the realities of computer technology, to learn how to use effectively the information resources computers make available to him?

It behoves us to define the sets of citizens to whom the efforts at education should be directed. We can distinguish three such sets: computer specialists, who need to be educated as to their responsibilities to consumers or customers of computer technology: adults who are already exposed to computer services and/or the products of computer applications; and young people, who can be brought up with a realistic understanding of how computers operate and the role of computers in our society.

a) The computer specialist is involved when a potential customer for computer services makes a conscious decision to use computers. Here the responsibility lies with the computer professional to design, operate, and maintain computer systems in such a way as to maximize the service to the customer and minimize possible adverse reactions. We "must recognize that the computer specialist who develops a system used by the public will certainly affect the public".(4) The quality of the systems produced by the specialists, and the use which is made of these systems, will determine whether they have good or bad effects on society.
   This philosophy must be incorporated into the curricula of computer science departments in our colleges and universities. And, in turn, computer specialists must learn to communicate meaningfully with the public, to present a fair picture of the computing industry.
b) In the case of the recipient for computer services, he has generally not made a conscious choice. Most of us suddenly begin to receive, for example, computer-processed bills or computer-addressed mail. We experience definite frustrations when we find that our normal, traditional methods for bringing errors in bills or in labels to someone's attention no longer work when that someone is a computer. The problem is not the computer but the management arrangements made - or, rather, not made - for coupling the computer to the consumer. The responsibility here must lie with both the computer professional, as described above, and with those involved in traditional educational channels. Not only the usual school systems but those means for consumer education sponsored by industrial and consumer oriented organizations must be used.
   Exposure of the adult consumer to the role of the computer can take the form of programs on public television networks, sponsored and prepared by professional and technical organizations in the computer field, industrial or governmental agencies using computers in their operations, and consumer groups experienced in techniques for reaching the layman on technical subjects. Eye-catching literature to appeal to the casual reader can also be used to carry the message about computers and their impact.
c) Ideally, education about computers and training in the ways of computers should begin at as early an age as possible. As an example, in the school system on the St. Paul-Minneapolis-Minnesota area of the United States, a joint board for data processing started to investigate the potential

> use of electronic data processing in elementary and secondary education ten years ago. With the latest in computer hardware and a staff trained both in computer technology and teaching, the board operates as Total Information for Educational Systems (TIES) and aids students from kindergarten through the twelfth grade. For demonstrations of a computer's ability, a portable teletype and data link to connect to the time-sharing computer at the TIES center are carried to member schools. From a simple example of communication with the computer, the demonstration goes on to show how the computer can add and do other simple arithmetic operations rapidly and without errors. In this way, the young children gain a first-hand appreciation of the operation, uses and benefits of a computer, along with an initial correction of many of their misconceptions.
>
> Junior high school students get opportunities to write and run their own programs, through the time share terminals located in their schools. The greatest emphasis on the study and use of the computer is in the high schools. The goals of the TIES program are threefold: to use the computer as an object of instruction, and understanding what it can do; to use the computer as a means of computer-aided instruction; and to develop an appreciation and awareness of the role of the computer in society. Since the high school students will be the first to feel the impact of the computers in their lives, they receive the greatest amount of instruction about it. (5)

CONCLUSIONS

We started this discussion in terms of the impact on our social structures due to the introduction of computer technology, and attendant communications and information technology, into our economy and society. Having recognized the need for education of computer specialists and consumers or private citizens in the ways of computer technology, we have examined possible solutions to the problem of introducing this education or training for computer science into the education system.

It is our belief that introduction of such training is necessary to ensure that the consequences of computer applications be orderly growth and development, rather than the sometimes confused and disruptive reactions of today. Until the consumer, the customer for and recipient of computer-based services, is fully aware of the implications for him of the developments in computer and attendant technologies, he will not support the continued growth of the field.

The successful application of computer technology is having, and will continue to have, impacts on the structure of our society. We must work together, as customers for and providers of computer services, to accomplish those activities that encourage the disciplined development of computer systems that will make possible better public services, better quality and lower cost industrial products and services, and better management of all organized activities. There has been a steadily growing recognition of the role of computers and computer networks in meeting the requirements of the developing economies of the world. We must also ensure recognition of the need for education and training of computer specialists and the private citizen to prepare us and our society to take full advantage of the promise of computer technology.

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XII

DEMAND FORECAST SURVEY OF INFORMATION PROCESSING ENGINEERS IN JAPAN

by

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There are four surveys in Japan on the demand forecast of Information Processing Engineers. The following is a summarised list of these surveys.

Abbreviation	Conducted by	Announced in	Period covering	Obsolescence	Remarks
J-1	JIPDEC	Sept.'68	1968 & 1972	Obsolete	
J-2	JIPDEC	June '69	1972 & 1975	Active	
J-3		March'71	1970 & 1976	(Active)	Limited circulation
E	MOE	Oct. '71	1972 - 1980	Active	SE & PR only

JIPDEC = Japan Information Processing Development Centre
MOE = Ministry of Education

Abbreviations used:

IP = Information Processing
L = Super large and large size computers
LA = Super large size computers
LB = Large scale computers
M = Medium size computers
MA = Medium size computers -- larger
MB = Medium size computers -- smaller
S = Small size computers
SS = Smaller size computers (excluding mini-computers)
SA = Systems Analysts

SE = Systems Engineers
PR = Programmers
SP = Senior Programmers
JP = Junior Programmers
OP = Machine Operators
KP = Key Punch Operators
MGR = Managers
TOT = Total
F.Y.= Fiscal Year

Notes:

1. The Japanese fiscal year starts in April and ends in March of the following year. For example, the 1972 fiscal year starts April '72 and ends March '73. Usually all statistics measured are as of the end of the fiscal year (i.e. March 1973 for the 1972 fiscal year).
2. The conversion rate between Japanese yen and U.S. dollars was 360:1 until August of 1971, but after that it changed to 108:1 (16.9% up).
3. The definition of computer system size is as follows:

System Size	Sales Price Range ($1,000)
L	812 and above
LA	1,623 and above
LB	812 and above
M	130 and above
MA	325 and above
MB	130 and above
S	32.5 and above
SS	under 32.5

Abbreviation : Survey J-2.
Conducted by: Information Technology Prediction Subcommittee,
Japan Information Processing Development Centre (JIPDEC).
Published under the title of: "Future of Information Processing Technology" (pp.197-223).
Announced in: June, 1969.
Period covered: 1972 and 1975.

Notes:

1. This publication consists of nine chapters focusing on the following topics:
   a) System Architecture
   b) Hardware Technology

139

c) Software Technology

d) Data Communication and Networks

e) Standardisation

f) Price Performance

g) Computer Professionals

2. This paper covers only (g) above.

A. BASIC DATA

The following data are quoted from estimates by the Ministry of International Trade and Industry, announced in July 1968.

1. Numbers of computers installed and of computers to be installed as of March 1972 and 1975 (estimates)

installed	1972	1975
LA	270	590
LB	790	1,650
MA	2,120	4,350
MB	2,570	5,420
S	4,230	8,890
SS	2,130	4,560
TOTAL	12,110	25,460

To be installed	1972	1975
LA	76	50
LB	221	130
MA	594	340
MB	920	420
S	1,184	680
SS	596	350
TOTAL	3,591	1,970

2. Value of computer production and computers imported (billion yen; $billion in parentheses)

	Production	Importation
1972 Fiscal Year	488(1.58)	48(0.156)
1975 Fiscal Year	927(3.01)	93(0.302)

B. METHOD

1. The adaptability of Brandon's Formula for this prediction was thoroughly investigated and verified and it became clear that if the adequate coefficients were selected, the modified Brandon's Formula could be used to fit unique Japanese conditions.

2. For simplifying and clarifying, this paper covers only the gist of the study, excluding several exciting detailed discussions and arguments.

3. Definition of systems sizes.

System sizes are broken down into categories as follows:

		elling Price Range
Super Large	(LA)	1.623 million and above
Large	(LB)	0.812 million and above
Medium - A	(MA)	0.325 million and above
Medium - B	(MB)	0.130 million and above
Small	(S)	32.5 thousand and above
Smaller	(SS)	nder $32.5 thousand

a) First, the demand forecast urvey was done by dividing into three sectors as follows:

i) Computer Users

Information processing services industry (service bureau type business)

ii) Computer Manufacturers

iii) Computer Dealers.

b) Computer Users

B-1

Standard numbers of I.P. Engineers per Computer System according to Brandon's Formula:

System Size	System Analyst	Programmer	Operator
LA	9.0	15.0	8.0
LB	4.0	8.0	5.0
MA	2.0	5.0	2.5
MB	2.0	5.0	2.5
S	0.5	1.5	1.5
SS	0.5	1.5	1.5

B-2

Standard numbers of I.P. Engineers per Computer System according to the modified Brandon's Formula for this survey:

Size	SA	PR	OP	TOTAL
LA	6.0	7.0	3.0	16.0
LB	4.0	5.0	2.0	11.0
MA	3.0	4.0	2.0	9.0
MB	2.0	2.5	1.5	6.0
S	0.5	1.5	1.5	3.5
SS	0.5	1.0	1.0	2.5

A

B-3

Increase of I.P. Engineers by additional shifts

i) Multiplying ratios by job title:

No. of Shifts	SA	PR	OP
1	1.0	1.0	1.0
2	1.2	1.2	2.0
3	1.4	1.4	3.0

B

ii) Increase of proportion of additional shifts in the future as of March, 1972:

Size	1 shift	2 shifts	3 shifts
LA	10%	55%	35%
LB	20%	55%	25%
MA	40%	50%	10%
MB	50%	40%	10%
S	80%	20%	-
SS	100%	-	-

C_{72}

as of March, 1975

Size	1 shift	2 shifts	3 shifts
LA	8%	50%	42%
LB	10%	50%	40%
MA	20%	60%	20%
MB	30%	60%	10%
S	50%	50%	-
SS	80%	20%	-

C_{75}

B-4

Adjusted numbers of I.P. Engineers per Computer System after considering the increases of additional shifts:

$A \times (B \times C_{72}) = D_{72}$

$A \times (B \times C_{75}) = D_{75}$

as of March, 1972

Size	SA	PR	OP	TOTAL
LA	7.5	8.75	6.75	23.0
LB	4.84	6.05	4.1	14.99
MA	3.42	4.56	3.4	11.38
MB	2.24	2.8	2.4	7.44
S	0.52	1.56	1.8	3.88
SS	0.5	1.0	1.0	2.5

D_{72}

as of March, 1975

Size	SA	PR	OP	TOTAL
LA	7.62	8.89	7.02	23.53
LB	5.04	6.3	4.6	15.94
MA	3.6	4.8	4.0	12.4
MB	2.32	2.9	2.7	7.92
S	0.55	1.65	2.25	4.45
SS	0.52	1.04	1.2	2.76

D_{75}

B-5

Brandon's Formula

The modified Brandon's Formula was used.

The original Brandon's Formula is as follows:

Size		Formula
Super Large	(LA)	$d = a + 0.6b$
Large	(LB)	$d = 0.95a$ % $0.6b$
Medium	(MA & MB)	$d = 0.7a + 0.7b$
Small	(S & SS)	$d = 0.75a + 0.8b$

where a = no. of installed systems

b = no. of systems to be installed at that time

c = adjusted no. of systems for prediction.

B-6

Modified Brandon's Formula

After several discussions and verifications, the following modified formula was adopted to calculate total numbers as of March 1972 and March 1975:

for 1972

Size	Formula
LA & LB	$d = a + 0.6b$
MA & MB	$d = a + 0.8b$
S & SS	$d = a + b$

$$\begin{bmatrix} 1 & 0.6 \\ 1 & 0.8 \\ 1 & 1 \end{bmatrix} E_{72}$$

for 1975

Size	Formula
LA & LB	$d = a + 3b$
MA & MB	$d = a + 2b$
S & SS	$d = a + 0.4b$

$$\begin{bmatrix} 1 & 3 \\ 1 & 2 \\ 1 & 0.4 \end{bmatrix} E_{75}$$

B-7

Total numbers of I.P. Engineers

According to the estimation by the MITI, numbers of installed systems and those of systems to be installed each year are as follows:

as of March, 1972

L	a	b
LA	270	76
LB	790	221
MA	2,120	594
MB	2,570	920
S	4,230	1,184
SS	2,130	596

F_{72}

as of March, 1975

a	b
590	50
1,650	130
4,350	340
5,420	420
8,890	680
4,560	350

F_{75}

$E_{72} \times F_{72} = G_{72}$

$E_{75} \times F_{75} = G_{75}$

	d
LA	316
LB	923
MA	2,595
MB	3,306
S	5,414
SS	2,726

G_{72}

	d
LA	740
LB	2,040
MA	5,030
MB	6,260
S	9,162
SS	4,700

G_{75}

for 1972 $G_{72} \times D_{72} = H_{72}$

Size	No.	SA	PR	OP	TOTAL
LA	316	2,370	2,765	2,133	7,268
LB	923	4,467	5,584	3,784	13,835
MA	2,595	8,875	11,833	8,823	29,531
MB	3,306	7,405	9,257	7,934	24,596
S	5,414	2,815	8,446	9,745	21,006
SS	2,726	1,363	2,726	2,726	6,815
TOT	15,280	27,295	40,611	35,145	103,051
		27,000	41,000	35,000	103,000

H_{72}

for 1975 $G_{75} \times D_{75} = H_{75}$

Size	No.	SA	PR	OP	TOTAL
LA	740	5,639	6,579	5,195	17,413
LB	2,040	10,282	12,852	9,384	32,518
MA	5,030	18,108	24,144	20,120	62,372
MB	6,260	14,523	18,154	16,902	49,579
S	9,162	5,039	15,117	20,615	40,771
SS	4,700	2,444	4,888	5,640	12,972
TOT	27,932	56,035	81,734	77,856	215,625
		56,000	81,500	78,000	215,500

H_{75}

Total numbers in computer users:

as of	SA	PR	OP	TOTAL
March, 1972	27,000	41,000	35,000	103,000
March, 1975	56,000	81,500	78,000	215,500

c) Computer Manufacturers

C-1

Standard numbers of I.P. Engineers in computer manufacturers

No. of Engineers per ¥1 billion ($3.25 million) production:

SA	Education Engineer	Sales Engineer	PR	TOTAL
20	3	11	25	59

J

C-2

Computer Production (estimated):

in 1972 F.Y. ¥488 billion ($1.58 billion) (a)

in 1975 F.Y. ¥927 billion ($3.01 billion) (b)

C-3

Total numbers in computer manufacturers

$J \times (a) = K_{72}$

$J \times (b) = K_{75}$

for 1972

SA	Ed.E	Sal.E	PR	TOTAL
9,760 ↓	1,464 ↓	5,368 ↓	12,200 ↓	28,792 ↓
9,700	1,500	5,400	12,000	28,600

K_{72}

for 1975

SA	Ed.E	Sal.E	PR	TOTAL
18,540 ↓	2,781 ↓	10,197 ↓	23,175 ↓	54,693 ↓
19,000	2,800	10,000	23,000	54,800

K_{75}

d) Computer Dealers

D-1

Standard numbers of I.P. Engineers in computer dealers

No. of Engineers per ¥ billion ($3.25 million) importation;

SA	Ed.E	Sal.E	PR	TOTAL
15	3	11	25	54

L

D-2

Value of imported computers (estimated)

in 1972 F.Y. ¥48 billion ($0.156 billion) (c)
in 1975 F.Y. ¥93 billion ($0.302 billion) (d)

(roughly 10% of computer production)

L x (c) = M_{72}
L x (d) = M_{75}

D-3

Total numbers in computer dealers

for 1972

SA	Ed.E	Sal.E	PR	TOTAL
720	144	528	1,200	2,592
730	140	530	1,200	2,600

M_{72}

for 1975

SA	Ed.E	Sal.E	PR	TOTAL
1,395	279	1,023	2,325	5,022
1,400	300	1,000	2,300	5,000

M_{75}

e) Summary

Table A

	SA	Ed.E	Sal.E	PR	OP	TOTAL
Users	27,000	-	-	41,000	35,000	103,000
Makers	9,700	1,500	5,400	12,000	-	28,600
Dealers	730	140	530	1,200	-	2,600
TOTAL	37,430	1,640	5,930	54,200	35,000	134,200
	45,000			= SE		

(as of March 1972)

Table B

	SA	Ed.E	Sal.E	PR	OP	TOTAL
Users	56,000	-	-	81,500	78,000	215,500
Makers	19,000	2,800	10,000	23,000	-	54,800
Dealers	1,400	300	1,000	2,300	-	5,000
TOTAL	76,400	3,100	11,000	106,800	78,000	275,300
	90,500			= SE		

(as of March 1975)

C. ANNOUNCEMENT

The result of the survey was announced in June 1969 and has been made available to the public in publication.

Table C

Just the same as Table 1
in Summary

(as of March 1972)

	SA	Ed.E	Sal.E	PR	OP	TOTAL
Users	56,110	-	-	81,560	77,920	215,590
Makers	19,000	2,800	10,000	23,000	-	54,800
Dealers	1,400	300	1,000	2,300	-	5,000
TOTAL	76,510	3,100	11,000	106,860	77,920	270,390*

(as of March 1975)

There are some minor discrepancies in the "users" line (perhaps due to adjustments).

* Clearly this is a misprint.

Abbreviation: Survey J-3.

Conducted by the third working group, Computer Utilization Upgrading Plan Committee, Japan Information Processing Development Center (JIPDEC).

Published under the title of: "Report of the Third Working Group, CUUPC, JIPDEC" (pages 93-112).
(Limited circulation, not available to the public)
Announced (restrictedly) in March 1971.
Period covered: 1970 and 1976.

Notes:

1. This survey consists of three independent parts, as follows:
    a) Sales Forecast of Information Processing Services Industry and Software Industry
    b) Sales Forecast of Information Offering Services Industry
    c) Demand Forecast of Information Processing Engineers.
2. This paper covers only (c) above.

A. BASIC DATA

Basic data of this survey are extracted from "Report of the First Working Group, Computer Utilization Upgrading Plan Committee, Japan Electronic Industry Development Association (JEIDA)" as follows:

Estimated Numbers of Computer Systems installed as of March 1976:

System Size		No.of Computer Systems
Large	(L)	2,900
Medium	(M)	9,700
Small	(S)	8,800
Smaller	(SS)	16,600
TOTAL		38,000

System size	Sales Price Range ($1,000)	Average Price ($1,000)
L	812 and above	2,727
M	130 and above	253
S	32.5 and above	75
SS	under 32.5	21

The following figures are quoted from the result of the Third Working Group, CUUPC, JIPDEC:

Total sales value of software industry in 1969 F.Y.
¥4 billion ($13 million)

Estimated sales value of software industry in 1975 F.Y.
¥251 billion ($0.81 billion)

Estimated sales value of computer manufacturers in 1975 F.Y.
¥900 billion ($2.92 billion)

Estimated value of installed computers, as of March, 1976 ¥3,500 billion ($11.36 billion).

Estimated sales of software industry to computer manufacturers in 1975 F.Y. ¥85 billion ($0.28 billion).

B. METHOD

1. The adaptability of Brandon's Formula for this forecasting was thoroughly investigated, but it became clear that Brandon's Formula had many ambiguous points which could not be understood and that it did not fit the unique conditions and customs in Japan.

2. There were, of course, several discussions, assumptions and approaches to reach this method, but we omit such detailed discussions, etc.,to simplify and clarify the gist of the method.

a) First, the demand forecast of Information Processing Engineers was done by dividing into three sectors as follows:

i) Computer Users
Information processing services industry
(service bureau type business);
ii) Software industry;
iii) Computer manufacturers.

b) Computer Users

B-1

Standard numbers of I.P. Engineers per Computer System

as of March 1970

System Size	SA	PR	OP	MGR	TOTAL
LA	6.0	7.0	3.0	2.0	18
LB	4.0	5.0	2.0	2.0	13
MA	3.0	4.0	2.0	1.5	10.5
MB	2.0	2.5	1.5	1.0	7
S	0.5	1.5	1.5	0.5	4
SS	0.5	1.0	1.0	0	2.5

as of March 1976

System Size	SE	SP	JP	OP	KP	TOTAL
L	5.2	9.1	14.3	6.7	31.3	66.6
M	5.2	2.5	3.7	3.0	9.5	23.9
S	2.5	1.0	2.0	2.0	3.8	11.3
SS	0.7	0.5	1.0	1.5	1.8	5.5

A

B-2

Total numbers of I.P. Engineers

System Size	No. of Computer Systems
L	2,900
M	9,700
S	8,800
SS	16,600

B

A x B = C

Size	SE	SP	JP	OP	KP	TOTAL
L	15,080	26,390	41,470	19,430	90,770	193,140
M	50,440	24,250	35,890	29,100	92,150	231,830
S	22,000	8,800	17,600	17,600	33,440	99,440
SS	11,620	8,300	16,600	24,900	29,880	91,300

C

B-3

Increase of I.P. Engineers by additional shifts

i) Multiplying ratios by job title

No. of shifts	SE	SP	JP	OP	KP
1	1	1	1	1	1
2	1.5	1.5	1.5	1.5	1.5
3	2.0	2.0	2.0	2.0	2.0

D

ii) Increase of proportions of additional shifts in computer users

as of March 1970

System Size	1 shift	2 shifts	3 shifts
L	30%	40%	30%
MM	60%	30%	10%
S	90%	10%	-
SS	100%	-	-

E

as of March 1976

System Size	1 shift	2 shifts	3 shifts
L	10%	50%	40%
M	30%	40%	30%
S	80%	20%	-
SS	100%	-	-

F

iii) Overall increase ratios by additional shifts

$$\frac{D \times F}{D \times E} = G$$

System Size	SE	SP	JP	OP	KP
L	1.1	1.1	1.1	1.1	1.1
M	1.2	1.2	1.2	1.2	1.2
S	1.05	1.05	1.05	1.05	1.05
SS	1	1	1	1	1

G

B-4

Adjusted total numbers of I.P. Engineers

C x G = H

Size	SE	SP	JP	OP	KP	TOTAL
L	16,588	29,029	45.617	21,373	99,847	212,454
M	60,528	29,100	43,068	34,920	110,580	278,196
S	23,100	9,240	18,480	18,480	35,112	104,412
SS	11,620	8,300	16,600	24,900	29,880	91,300
TOTAL	111,836	75,669	123,765	99,673	275,419	686,362

H

B-5

Increase of outside orders by computer users

i) Outside orders of software development by computer users

as of March 1970	2.0%	(a)
as of March 1976	25.0%	(b)

ii) Decrease of I.P. Engineers effected by the increase of outside orders

SE : 111,836 x $[1-(b-a)]$ = 111,836 x 0.77 = 86,114

SP : 75,669 x $[1-(b-a)]$ = 75,669 x 0.77 = 58,265

JP : 123,765 x $[1-(b-a)]$ = 123,765 x 0.77 = 95,299

B-6

Total numbers of I.P. Engineers in the first sector (computer users)

SE	SP	JP	OP	KP	TOTAL
86,114	58,265	95,299	99,673	275,419	614,770

c) Software Industry

C-1

Standard numbers of I.P. Engineers per ¥1 billion ($3.25 million) sales

$$\left(\begin{array}{ccccc} \underline{SE} & \underline{SP} & \underline{JP} & \underline{OP} & \underline{KP} \\ 71 & 89 & 38 & * & * \end{array}\right) = L \qquad\qquad L$$

*Numbers of OP and KP are already included in the "computer users" column, because the calculations (of standard numbers x numbers of computer systems) include all machine operators and key punch operators.

C-2

Total numbers of I.P. Engineers in software industry

Estimated sales value in 1975 F.Y.
(ending March, 1976) - ¥251 billion ($0.81 billion)

Adjusted value (equivalent to 1969 F.Y.)
251 / 1.12 = ¥224.1 billion ($0.73 billion) (f)

L x (f) = M

SE : 71 x (251 / 1.12) = 15,912
SP : 89 x (251 / 1.12) = 19,946
JP : 38 x (251 / 1.12) = 8,516

$$\left(\begin{array}{ccccc} \underline{SE} & \underline{SP} & \underline{JP} & \underline{OP} & \underline{KP} \\ 15{,}912 & 19{,}946 & 8{,}516 & * & * \end{array}\right) = M \qquad\qquad M$$

C-3

Total numbers in the second sector (software industry)

SE	SP	JP	OP	KP	TOTAL
15,912	19,946	8,516	-	-	(44,374)

d) Computer Manufacturers

D-1

Standard numbers of I.P. Engineers

per ¥1 billion ($3.25 million) investment for software development

$$\left(\begin{array}{cccccc} \underline{SE} & \underline{SP} & \underline{JP} & \underline{OP} & \underline{KP} & \underline{TOTAL} \\ 166 & \multicolumn{2}{c}{203} & 19 & 83 & 471 \end{array}\right) = J_1$$

per ¥ billion ($3.25 million) sales

$$\left(\begin{array}{cccccc} \underline{SE} & \underline{SP} & \underline{JP} & \underline{OP} & \underline{KP} & \underline{TOTAL} \\ 21 & \multicolumn{2}{c}{25} & 2 & 10 & 58 \end{array}\right) = J_2$$

After several discussions it was concluded to adopt J_2 rather than J_1 for calculation of I.P. Engineers.

D-2

Total numbers of I.P. Engineers in computer manufacturers

Estimated sales value in 1975 F.Y.
(ending March, 1976) : ¥900 billion ($2.92 billion) (c)

Estimated installed value as of March, 1976:
¥3,500 billion ($11.36 billion) (d)

J_2 x (c) = K

$$\left(\begin{array}{cccccc} \underline{SE} & \underline{SP} & \underline{JP} & \underline{OP} & \underline{KP} & \underline{TOTAL} \\ 18,900 & \multicolumn{2}{c}{22,500} & 1,800 & 9,000 & 52,200 \end{array}\right) = K$$

D-3

Decrease of I.P. Engineers effected by the outside orders from the manufacturers to software industry

Estimated outside orders in 1975 F.Y.:
¥85 billion ($0.28 billion)

Adjusted value (equivalent to 1969 F.Y.):
¥85 billion / 1.12 = ¥75.89 billion
($0.25 billion) (e)

SE : 18,900 -71 x (e) = 18,900 - 5,388 = 13,512

SP+JP : 22,500 - (89 + 38) x (e) = 22,500 - 9,638 = 12,862

SE	SP	JP	OP	KP	TOTAL
13,512	12,862		1,800	9,000	37,174

e) Summary

Sector	SE	SP	JP	OP	KP	TOTAL
Users	86,114	58,265	95,299	99,673	275,419	659,144
Software	15,912	19,946	8,516			
Makers	13,512	12,862		1,800	9,000	37,174
Total	15,538	194,888		101,473	284,419	696,318

L

(as of March 1976)

Comparison with numbers as of March 1970

Demand

Sector	SE	SP	JP	OP	KP	TOTAL	
Users	18,235	11,385	19,609	19,707	42,892	112,620	
Software	284	356	152				
Makers	4,460	5,310		425	2,214	12,409	
Total	22,979	36,812		20,132	45,106	125,029	M

(as of March 1970)

Actual

Total	15,924	28,235	16,166	38,430	98,755	N
%	69.3	76.7	80.3	85.2	79.0	N/M

(as of March 1970)

Comparison	SE	PR	OP	KP	TOTAL
L/M	5.0	5.3	5.0	6.3	5.6
L/N	7.3	6.9	6.3	7.4	7.1

C. ANNOUNCEMENT

The announcement was made in a limited circle calling for animated comments, but the publication has not been made available to the public.

Announcement

Sector	SE	SP	JP	OP	KP	TOTAL
Users	86,114	58,265	95,299	99,673	275,647*	659,372*
Software	15,912	19,946	8,516			
Makers	7,512*	12,103*		1,800	9,000	30,415*
Total	109,538*	194,129*		101,473	284,647*	689,787*

(as of March 1976)

Author's comments

Unfortunately there are some erroneous results which the author discovered. They are marked with an asterisk. They might be caused by some minor carelessness.

Abbreviation : Survey E.
Conducted by : Quantitative Measurement Working Group, Panel on Information Processing Education, Ministry of Education (MOE).
Published under the title : "Information Processing Engineer Training Program - A Quantitative Survey" (pp.65).
Announced in : October 1971.
Period covered: 1972 through 1980.

Notes:

1. This survey covers not only the demand forecast of Information Processing Engineers but the manpower supply forecast in many cases without any counter-measure, establishment of special departments on Information Processing, steering programme of general I.P. education for all students, etc. and cost analysis and effect survey of such cases.
2. The summarized contents of the publication are as follows:
   a) Demand forecast of Information Processing Engineers,
   b) Supply forecast in the case without any counter-measure,
   c) Effect of establishment of special departments,
   d) Steering programme of general I.P. education for all students,
   e) Cost analysis of the general I.P. education programme,
   f) Effect of the general I.P. education programme.
3. This paper covers only a part of the above item (a).

A. BASIC DATA

Basic data of this survey are extracted from Survey (J-2).

as of	Systems analyst	Sales engineer	Education engineer	Programmer	Operator	Total
March '72	37,430	5,930	1,640	54,200	35,000	134,200
March '75	76,510	11,000	3,100	106,860	77,920	275,390

In this survey, "systems engineer" is defined as a generic term combining system analyst, sales engineer and education engineer in the Survey (J-2).

The item of "operator" is omitted, resulting in the following figures:

as of	Systems engineer	Programmer	Total
March, 1972	45,000	54,200	99,200
March, 1975	90,160	106,860	197,470

B. METHOD

There were many discussions, assumptions and approaches concerning Japanese educational systems, training programmes, labour conditions, labour customs, computer industry forecast, etc.

However, to simplify and clarify the forecasting method of this survey, we omit such discussions and introduce only the outline of the method.

It is self-explanatory.

as of	SE	PR	TOTAL
March 1972	45,000 (A)	54,200 (C)	99,200 (E)
March 1975	90,610 (B)	106,860 (D)	197,470 (F)

1. Yearly Growth Ratio

   (B) / (A) = 2.014

   Average Yearly Growth Ratio (SE) = 1.263

   (D) / (C) = 1.972

   Average Yearly Growth Ratio (PR) = 1.254

   (F) / (E) = 1.991

   Average Yearly Growth Ratio (Total) = 1.258.

   Then we assume Average Yearly Growth Ratio ≒ 1.26 during 1975 through 1980 generally.

2. Yearly Growth Number

   [(B) - (A)] / 3 = 45,610 / 3 = 15,200 (SE)

   [(D) - (C)] / 3 = 52,660 / 3 = 17,550 (PR)

   [(F) - (E)] / 3 = 98,270 / 3 = 32,750 (Total).

3. Numbers estimated by multiplying by Average Yearly Growth Ratio 1.26 may be the maximum demand limit, and numbers estimated by adding Average Yearly Growth Number may be the minimum demand limit. Then we take average [(Max.) + (Mini.)] / 2 as Yearly Forecasted Number. (See Table on the following page.)

Year*	Systems Engineer			Programmer			Total
	G	H	Average (I)	J	K	(Average (L)	(I)+(L)
	x1.26	+15,200	(G+H)/2	x1.26	+17,550	(J+K)/2	
1972		45,000			54,200		99,200
1973	56,700	60,200	58,450	68,300	71,750	70,030	128,480
1974	71,400	75,400	73,400	86,000	89,300	87,650	161,050
1975		90,610			106,860		197,470
1976	114,100	105,810	109,960	134,600	124,410	129,500	239,460
1977	143,800	121,010	132,410	169,600	141,960	155,780	288,190
1978	181,200	136,210	158,710	213,700	159,510	186,610	345,320
1979	228,300	151,410	189,850	269,000	177,060	223,030	412,880
1980	287,700	166,610	227,150	339,000	194,610	266,810	493,960

* As of March of each year.

C. ANNOUNCEMENT

The following result has been announced, but there may be some erroneous points which are explained by the author's comments.

Fiscal Year*	Systems Engineer	Programmer	Total
1972	45,000	54,200	99,200
1973	58,450	70,030	128,480
1974	73,400	87,650	161,050
1975	90,610	106,860**	197,470**
1976	109,960	129,490	239,450
1977	132,410	155,780	288,190
1978	158,710	186,610	345,320
1979	189,850	223,030	412,880
1980	227,150	266,810	493,960

Author's comments:

* Usually time means "the end of the fiscal year", then "fiscal year 1972" means "as of March 1973". Consequently this column must be corrected as "1971, 1972 ... 1979".

** Minor calculation errors: 129,500 and 239,460 are correct.

Annex

SEMINAR ON TRAINING POLICIES FOR COMPUTER MANPOWER AND USERS

Paris, 21st, 22nd, 23rd May, 1973

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